PRELIMINARY STUDY FOR SITING THE SUPERCONDUCTING SUPER COLLIDER IN NEW MEXICO

Interim Report On The Northern Estancia Basin Site

Prepared For:
SSC SITING EVALUATION COMMITTEE

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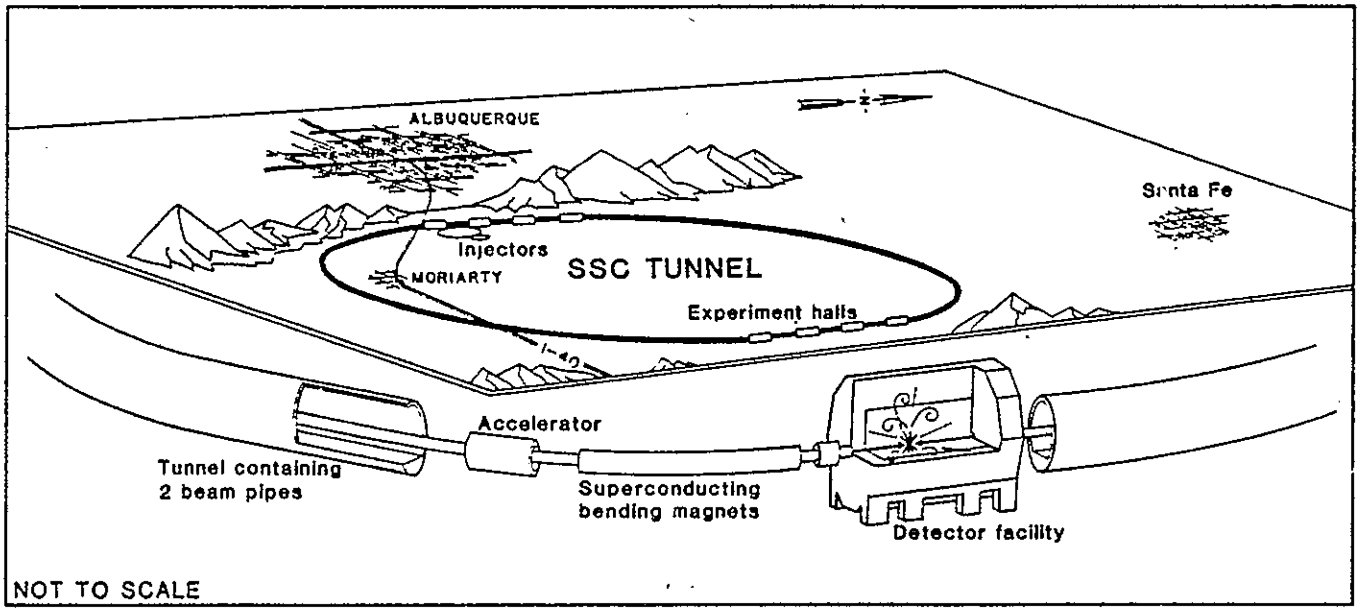

NEW MEXICO BUREAU OF MINES & MINERAL RESOURCES
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JANUARY 15, 1987

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1.0 EXECUTIVE SUMMARY

1.1 Introduction

A geotechnical investigation within the northern Estancia Valley, approximately 40 mi east of Albuquerque (Fig. 1) is being conducted by New Mexico Bureau of Mines and Mineral Resources (NMBMMR). The objective of the study is to determine if there are any geologic or geotechnical conditions ("fatal flaws") that would preclude siting of the Superconducting Super Collider (SSC) in the valley. The 10 month-long study is now 80 percent complete. This report summarizes the important findings of the study. It is the first of two reports and is being presented in this abbreviated version to provide decision makers with the study's results on a timely basis. This report has been placed on open-file (OFR 257) at NMBMMR so that it is readily available to the public. The second and final report will be completed by March 31, 1987. It will include all laboratory test results as well as final boring logs and trench logs, and maps. However, the conclusions contained in the final report should not differ significantly from those in this report.

The SSC will be a scientific instrument for studying the fundamental nature of matter. A tunnel containing two adjacent tubes will be used to guide ultra high-energy protons in opposite directions at nearly the speed of light. At various locations along the SSC tunnel the protons will collide, creating subnuclear particles. This will provide physicists with an opportunity to witness conditions likely

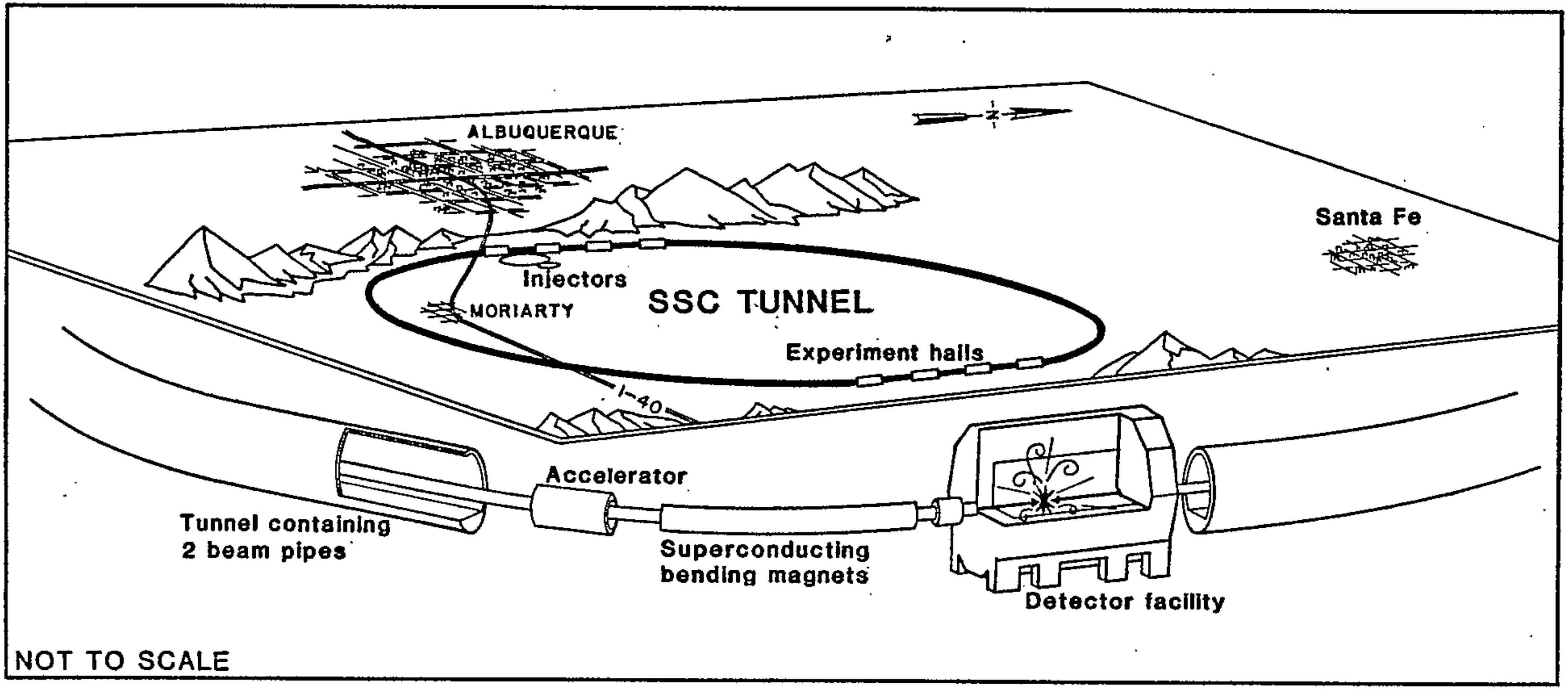

Figure 1-1. Location map for SSC study area.

to have occurred at the inception of the universe.

If Congress funds the project, it will take about six years to construct, at a funding level of 500 million dollars per year. The state selected for the project will receive an enormous amount of out-of-state money that will spawn numerous new businesses. Considerable growth will take place in the SSC site region when administrative and technical personnel move in and scientists from around the world visit the facility. To support their needs, new housing, laboratory, warehouse, and industrial construction will be required in and around the site.

1.2 Background

The origins of the SSC date to 1983 when the High Energy Physics Advisory Panel (HEPAP) of the U.S. Department of Energy endorsed earlier subpanel recommendations for construction of a multi-TeV, high luminosity, proton-proton collider. HEPAP concluded that construction and operation of the SSC is within reach of present-day technology. To date there has not been a specific call for proposals, nor has the SSC been funded. Studies to locate a suitable site are being conducted currently in at least 17 states (at state expense) in an attempt to secure location of the facility into each state. Based upon reports by two SSC siting committee members who attended the third SSC site conference held in Columbus, Ohio, on October 31-November 1, 1986, the northern Estancia Valley site is competitive with sites in other states and is technically within the top third of the sites under consideration nationally.

The SSC effort in the United States is supported by the U.S. Department of Energy through grants and contracts to the Universities Research Association (URA). The URA formed the Central Design Group (CDG) to direct and coordinate the national research and development (R&D) work. The CDG has produced two important documents that have been used for this study. The first is the SSC Siting Parameters Document (SSC Central Design Group, 1985) and the second is the Conceptual Design of the Superconducting Super Collider (SSC Central Design Group, 1986). The Siting Parameters Document summarizes siting criteria and enumerates site-specific information important for evaluation of potential sites. The Conceptual Design report describes the instrument in detail and incorporates the results of all R&D to date. It presents a discussion of the scientific needs, SSC design, cost estimate, and construction schedule.

New Mexico began a study of the SSC in 1983 (Public Service Company of New Mexico, 1983). That study describes the natural and human environment of a proposed site between Deming and Las Cruces; the site was flawed by unstable soils conditions relating to localized overuse of ground water. In 1985, at the request of the SSC Siting Committee, the New Mexico Bureau of Mines and Mineral Resources (NMBMMR) produced a technical report on the northern Estancia Valley (NMBMMR, 1985). The current NMBMMR study to characterize conditions in the Estancia Valley is at the request of the

SSC Site Evaluation Committee and began June 2, 1986 (see activity location map, Appendix I). Field work and most laboratory analyses on soil and rock samples (Tables 4-1 and 4-2) have been completed.

1.3 Scope of this study

To achieve the objective of this study, the following tasks were undertaken for the 650 mi^2 study area (Fig. 1-1).

- Literature survey

  A comprehensive review of geologic, hydrologic, utility capacity, and infrastructure literature available for the site region.

- Aerial photograph analysis

  Study of existing stereo aerial photographs of the site including color and black-and-white photographs at a variety of scales and vintage. The purpose of studying the aerial photographs was to delineate geologic units and identify land use patterns.

- Engineering geologic mapping

  Mapping of engineering geologic units within the site area (map not included in this report).

- Drilling

  Drilling, sampling, and logging of 29 drill holes averaging 35 feet deep (Appendix I). The purpose of the drilling was to extrapolate surface data to tunnel depths.

- Geophysical reflection survey

  Conducting a 7,000-foot-long geophysical survey to characterize near-surface soils (upper few hundred feet) in a structurally anomalous area.

- Seismicity review

  Acquiring and analyzing all seismicity records for the study area.

- Land ownership documentation

  Determining general patterns of land ownership within the private, state, and federal sectors. Documenting areas of prime farmland and locations of existing subdivisions. General land values were determined.

- Infrastructure analysis

  Documenting social, economic, cultural, and industrial resources of the site region (including Albuquerque metropolitan area).

- Utility capacity documentation

  Identifying location and capacity of local utility companies including telecommunication, electrical transmission lines, and pipelines.

- Archeological surveys

  Compiling existing data on archeologic and historic sites within the study area. Any new sites discovered were noted.

- Shallow trench logging

  Excavating, shoring, and logging in detail the shallow soils (upper 12 feet) in nine backhoe trenches (Appendix I). Representative soils were sampled for laboratory testing.

- Soil and rock sample collection

  Collecting samples of soil and rock from natural exposures, hand-dug pits, quarries, roadcuts, drill holes, and backhoe trenches.

- Laboratory testing

  Geotechnical testing of soil and rock specimens. Emphasis was placed on tests that characterize tunnel conditions. Specific tests are: Atterberg Limits; soil moisture, density, and gradation; rock point load assessment; thin section petrography, and rock density.

- Report writing

  January 15, 1987 -- Summary report to the SSC Site Evaluation Committee, incorporating preliminary conclusions, and available laboratory data.

  March 31, 1987 -- Detailed technical report containing final conclusions and results of all laboratory tests.

1.4 Conclusions

The present NMBMMR investigation of the northern Estancia Basin did not identify any geotechnical "fatal flaws" that would preclude siting the SSC there. In the site, the tunnel would be mostly in older, partly cemented alluvium and in sedimentary rock above the regional water table. An adequate utility capacity and regional infrastructure exists to support construction and operation of the SSC. Resources of the Albuquerque metropolitan area would be drawn upon to meet many of the SSC demands (labor, housing, etc.). During the study three areas of concern were identified: 1) potential for ground subsidence due to ground water withdrawal and potential for ground subsidence due to rock solution at depth, 2) tunneling conditions need to be confirmed because tunneling costs will be a large percentage of construction costs, and 3) ground water quality/availability needs to be quantified because the region relies heavily on ground water for domestic wells. Resolution of these uncertainties were beyond the scope of this study and requires further geotechnical evaluation. Although the chances are small, if there is a high potential for ground subsidence (concern number 1), it would be a "fatal flaw", and the northern Estancia Valley would no longer be a viable SSC site. The remaining two concerns should also be resolved because they have great impact on the cost of tunneling and subsequent operation of the facility.

1.5 Recommendations

To resolve the three concerns listed in Section 1.4, it is recommended that a geotechnical site verification study be implemented as soon as possible. If DOE requests a proposal on short notice, New Mexico will then be prepared to respond. The geotechnical site verification study should include the following work elements:

1) drilling, sampling, and logging of up to 27 drill holes (averaging 120 feet deep) at selected localities along the SSC tunnel,

2) conducting geophysical surveys (surface and downhole) to extrapolate drill hole data,

3) conducting engineering geologic mapping at sufficient detail (1:62,500) to identify any potentially adverse conditions,

4) laboratory testing of soil and rock samples obtained from drill holes; emphasis should be placed on testing for ground subsidence potential and confirming tunneling conditions, and

5) report writing with a strong recommendation section on site suitability.

A separate proposal and budget to verify geotechnical conditions and resolve the above three concerns accompanies this report.

2.0 SETTING

The scale of the SSC is its most notable feature. In areas where the tunnel is greater than 40 feet underground (Fig. 2-1) and where there are no SSC surface buildings, land could be co-used with others. A band of land totalling 17 mi^2 in area (above the tunnel) will encircle an area of several hundred square miles that will be unaffected, allowing continued use and habitation.

Figure 2-1 Subsurface conditions around SSC perimeter.

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2.1 General

The northern Estancia Valley is well suited as a location for the SSC facility. There is no perennial surface water, the topography is flat to gently sloping (small hills are located only in the southwestern area of the facility), a minimum of endangered vegetation and animal life exists, the population density is low (approximately 2.5 persons/mi^2), and only the southwestern part of the proposed site has any appreciable residential development. These attributes are discussed in more detail in Sections 3.0, 4.0, and 7.0 of this report.

The New Mexico Bureau of Mines and Mineral Resources SSC staff have determined the best fit for the SSC tunnel in the Estancia Valley using two models (Fig. 2-1). The first (terrain fitted) model uses alternating magnet clusters of differing orientations to allow placing the tunnel close to the ground surface The terrain fitted model, if used, may reduce tunneling costs significantly. The second model uses the SSC Central Design Group (1986) parameters that allow tilting and folding of the SSC tunnel plane in order to accommodate valley topography. The model used in this report and for the accompanying proposal and budget is based on the latter model with the tunnel tilted to the south 0.20° and folded in the west at an angle of 0.30°. The east side of the SSC tunnel is horizontal. The placement of the SSC within the study area is based mostly on the following: surface topography, hydrogeology, depth to rock, depth to water table, land use, utility availability, and proximity to Albuquerque.

2.2 Land commitment

The SSC complex will occupy approximately 11,000 acres. Five thousand acres will require exclusive SSC use (fee simple) for the campus, service, injector, and experimental areas. Approximately 1,000 acres will require right-of-way easements for roads and utilities.

In areas where the tunnel is greater than 40 feet deep and where there are no SSC surface buildings the land can be co-used with priority of use (by easements) granted to the SSC. However, areas where the tunnel is constructed at shallow depths (less than 40 feet deep and using cut-and-fill methods) require exclusive SSC use of the land.

The majority of the land within the SSC site is privately owned. The trace of the proposed SSC tunnel does not cross federally owned land; however, it does cross four sections of state-owned land, which are currently being leased to ranchers.

2.3 Institutional setting

Local statutes and jurisdictions affect the SSC and need to be examined. Areas of interest to the SSC include: subsurface easements; mineral, oil, and gas rights; water-rights ownership; air-rights policies; and an analysis of the loss of tax revenues currently derived from land slated for SSC use. Services such as fire protection, schools, roads, etc., may be affected by such changes. Analysis of these possible impacts beyond the scope of this study.

2.4 State and local support

The support of state and local government is essential to the construction of the SSC. A timely commitment must be made on the part of state and local government and industry to provide the SSC with the necessary utility and transportation facilities. Utility companies and local officials in the Moriarty area have already expressed strong verbal support for the SSC project.

3.0 ENVIRONMENT

The SSC should be constructed and operated with minimal and acceptable environmental impact. Before SSC construction begins, an Environmental Impact Statement (EIS) will be completed. During construction and operation the requirements of the National Environmental Policy Act (NEPA) will have to be met (SSC Central Design Group, 1985).

3.1 Land use

Land use within the study area is critical in determining the environmental impact from the SSC. Most of the Estancia Valley is rural grazeland, which predominates in the north and east, and irrigated cropland along the central area. Urban centers and subdivisions are clustered in the central and western parts of the valley (in McIntosh, Moriarty, Stanley, and Edgewood). Some areas are designated as prime irrigated farmland by the Soil Conservation Service (Fig. 3-1). No areas of wetlands or unique farmlands are

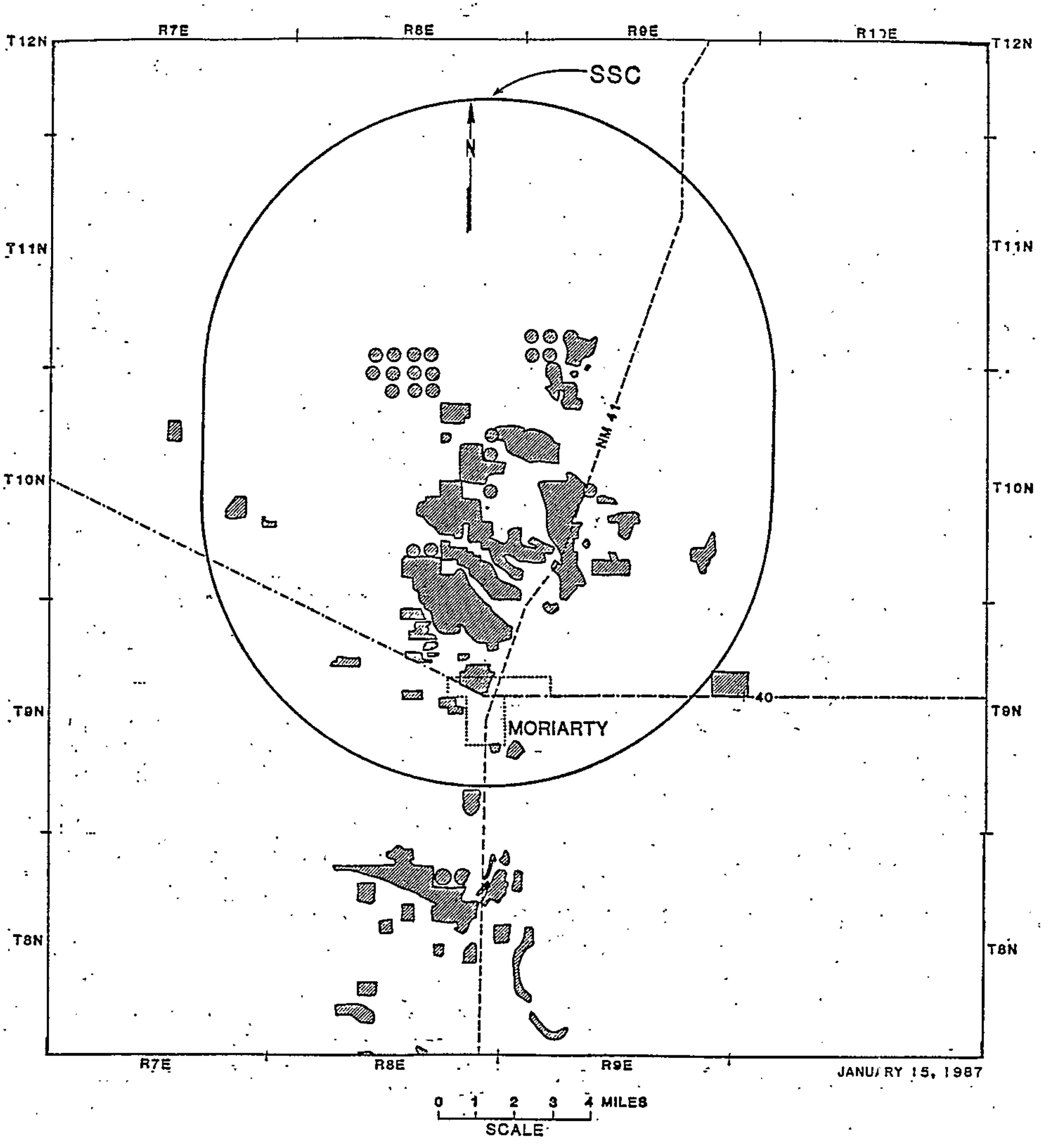

Figure 3-1. Areas designated as prime irrigated farmland (Soil Conservation Service, 1982, 1984).

present in the study area (Soil Conservation Service, 1982, 1984). Land uses adjacent to the study area include Cibola National Forest along the western mountains, the Isleta Pueblo land grant to the southwest, and the Sandia Military Reservation to the west. At no point does the SSC tunnel cross federal land but it does cross four sections of state land (Fig. 3-2).

3.2 Surface and subsurface water

The northern Estancia Valley is a closed drainage basin with an average annual precipitation of 12 inches per year (Smith, 1957). All streams in the study area are ephemeral. In very wet years (e.g., 1986) some arroyos may flow and some "wallows" contain water.

The principal source of water for domestic and livestock use is the valley fill; most wells range in depth from 100 to 300 feet below the surface. The New Mexico State Engineer's Office and U. S. Geological Survey (USGS) monitor water well levels routinely (Smith, 1957 and pers. comm., Robert White, U.S. Geological Survey, 1986). Better quality water is produced from wells drilled west of NM-41, and water of lesser quality is produced from wells east of the highway. More complete data on both water quality and availability are required (see Section 1.4).

The operation of the SSC facility is not expected to have an adverse effect on surface water drainage patterns or water quality of the subsurface wells in the study area. During heavier storms (mostly in the summer) there may be a

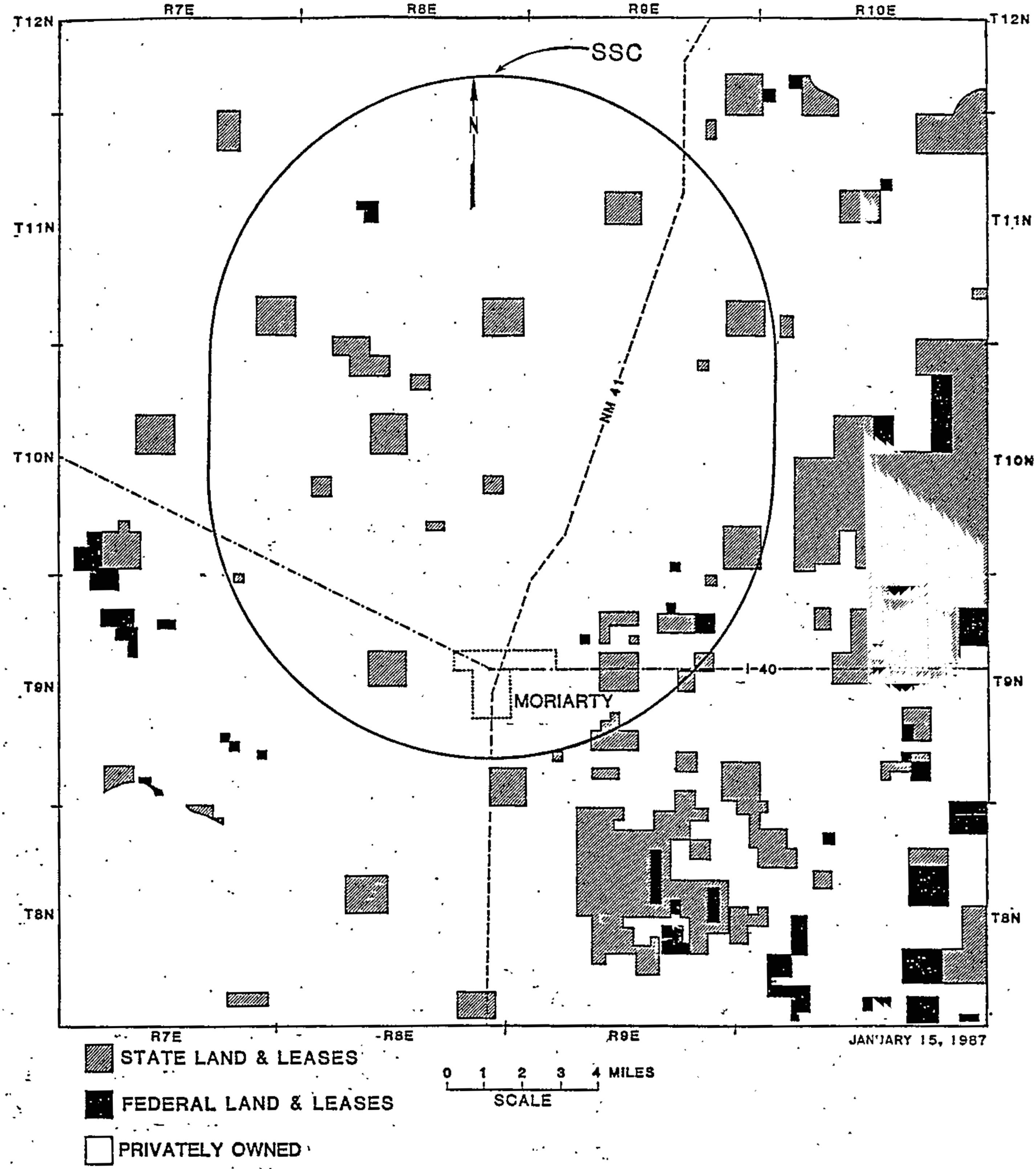

Figure 3-2. Federal and State owned land in the SSC study area (Bureau of Land Management, 1982).

slight increase in sediment load in surface runoff during construction.

3.3 Ecology

Vegetation within the study area is predominantly grasses and desert plants. Only one plant species may be considered in the future for federal protection (pers. comm., Ann Cully, New Mexico Natural Resources Department, 1986). The New Mexico Department of Game and Fish (1983) lists three species of birds as endangered species that were possibly sighted within the SSC study area. No federal or state nature preserves or parks are present within the SSC study area.

3.4 Air quality

The air quality at the SSC site will be affected little by the project during operation. The air quality in the Estancia Valley exceeds ambient standards (pers. comm., Bob Kirkpatrick, Air Quality Bureau of Environmental Improvement Division, 1986) and standard measures will be adequate to control any dust generated by construction (e.g., wetting).

Placement of the SSC facility in the Estancia Basin requires obtaining Federal Prevention of Significant Air Deterioration (PSD) permits before construction begins. Obtaining a PSD permit requires on-site monitoring data. Currently, the EID monitors particulate matter in the Estancia Valley and has six years of data available. In addition, air quality modelling can be used to gauge the impact that secondary growth, commuting traffic, and other associated sources would have on the existing air quality.

3.5 Background radiation

The radiation levels measured for air, water, and soil in the Estancia Valley fall within New Mexico and federal guidelines (pers. comm., David Baggette, Radiation Protection Bureau of the Environmental Improvement Division, 1986). The radiation level for air is slightly below the mean value (Geometrics, 1979). Similarly, radiation for water and soil in the valley is below the level considered as background by state and federal agencies (Olsen, 1977; pers. comm., David Baggette, Radiation Protection Bureau of EID, 1986).

In the event of a beam loss, radiation leakage from the SSC facility is expected to be nil. The SSC tunnel will average 87 feet below the ground surface and at all times the tunnel will be greater than 20 feet below the surface. Shielding from 20 feet of soil is considered sufficient to restrict surface-dose rates of radiation to permissible levels if a beam is "lost" during SSC operation (SSC Central Design Group, 1985). In most cases though, a system failure (unauthorized entry into the tunnel, magnet failure, equipment failure, etc.) would be minimized by incorporation of a beam dump into which the beam could be safely routed.

3.6 Historical and archeological resources

Construction of the SSC facility will have a minimal impact on archeological and historic sites. There are five previously recorded archeological sites located within the SSC facility area (pers. comm., Rosemary Talley, Laboratory of Anthropology, State Office of Cultural Affairs, 1986). Before construction, a thorough archeological survey will be conducted along the surface trace of the SSC. Where sites occur arrangements will be made with the state archeologist and/or landowners for proper excavation and preservation of artifacts. Avoidance measures will be taken to the maximum extent possible.

The National Register of Historic Places lists no historic sites within the SSC study area (pers. comm., Daniel Reiley, New Mexico Historic Preservation Division, Office of Cultural Affairs, 1986). If any historic buildings are encountered, all possible means will be taken to protect and preserve their integrity.

4.0 GEOLOGY AND TUNNELING

4.1 General location

The northern Estancia Valley SSC study area covers 650 mi^2 and is approximately centered on the Torrance-Santa Fe County line three miles north of Moriarty (40 miles east of Albuquerque). A small portion of Bernalillo County is contained along the western edge (Fig. 4-1). Moriarty, a community of 1,500, lies in close proximity to the proposed trace of the SSC tunnel. The smaller communities of Cedar Grove and Stanley are also close to the proposed SSC tunnel.

Estancia Valley is a broad, nearly flat floored

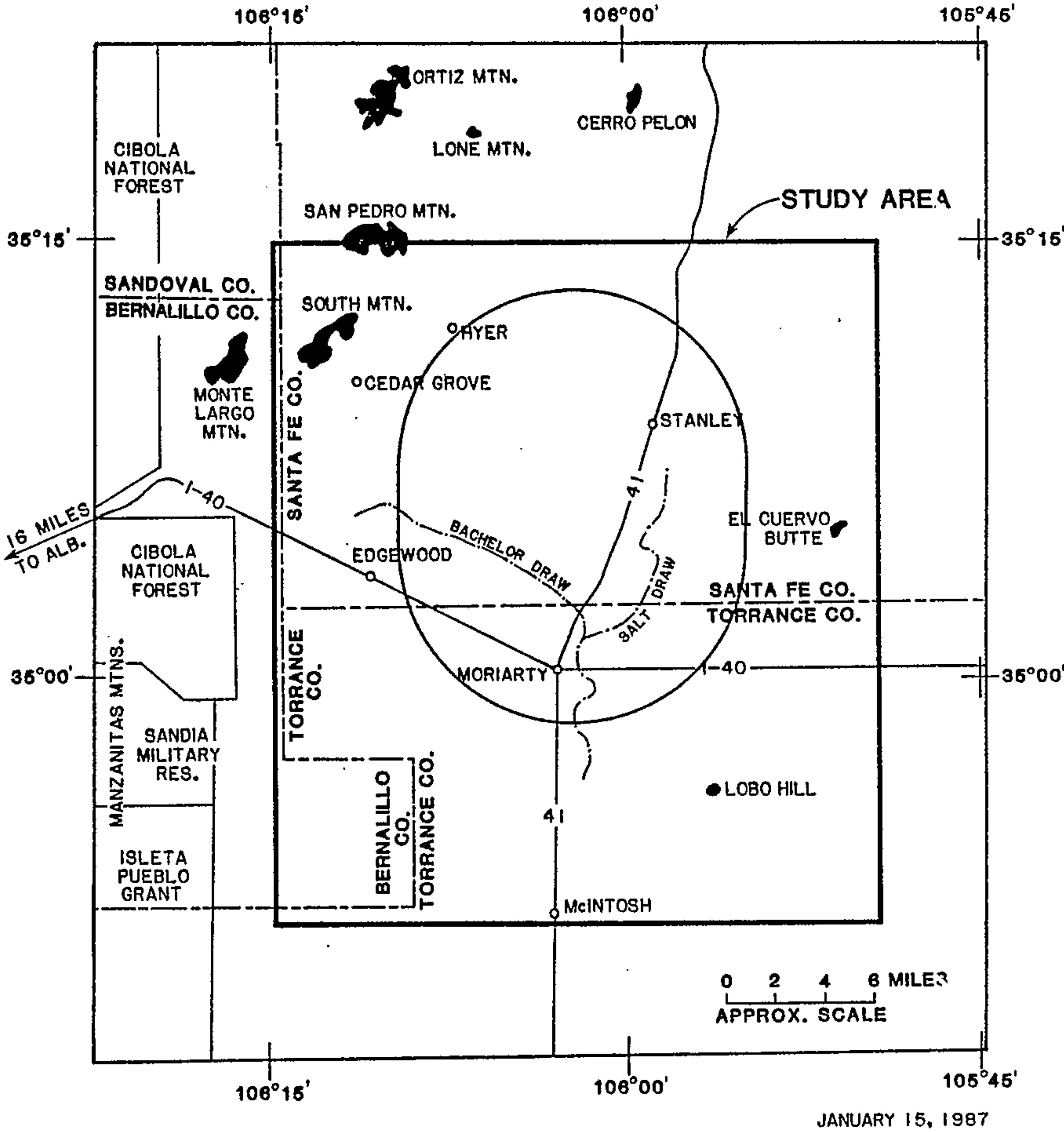

Figure 4-1. Regional Location Map.

intermontane basin bounded by the Manzano-Manzanitas-South Mountain-San Pedro Mountain chain on the west and the Pedernal uplift and Glorieta Mesa on the east. The Estancia Valley floor is an elliptical area covering approximately 450 mi2 enclosed within the 6,200-ft elevation line of topographic maps. The main valley floor is largely south of the SSC study area but does extend northward near Moriarty. The average elevation of the main valley (6,100 ft) is much lower than that of the northern Estancia Valley area studied for this report (6,339 ft).

The study area is bounded on the west by the northern Manzanitas Mountains with crestal altitudes ranging between 7,000 and 8,000 ft. The northwest portion of the area is bounded by South Mountain and San Pedro Mountain. The northern part is bounded by a drainage divide with steep slopes to the north toward Galisteo Arroyo and more gentle slopes southward. The eastern side of the study area is bounded by low hills that form a broad drainage divide between the northern Estancia Valley and tributaries of the Pecos River to the east. The southeast portion of the area contains Lobo Hill, a prominent topographic feature visible for miles around.

The slope of the valley floor is approximately 15 feet per mile toward the south but locally is somewhat greater (70 feet per mile near Hyer). The elevation of the ground surface along the proposed SSC tunnel varies from 6,700 ft near Cedar Grove to 6,175 ft in Salt Draw near Moriarty. The average surface elevation along the SSC tunnel is 6,423 ft.

4.2 Geology

A variety of bedrock units are exposed in the study area; mainly around its margins. However, bedrock is exposed in only a few places along the trace of the SSC tunnel. The rocks are buried mainly by basin fill (Cenozoic) consisting of alluvium and lake deposits. The mostly unconsolidated sediments are as much as four hundred feet thick near Moriarty. The bedrock units that will be encountered by the SSC tunnel are, in general, sedimentary rocks consisting of sandstone, limestone, shale, and possibly some interbedded evaporites. General descriptions of the rocks are given below; laboratory test values are given in Table 4-1. Where not highly fractured, the rocks encountered should stand without a great deal of support when tunneled. Where highly fractured, tunnel stand-up time will be controlled mainly by the nature of fracture-filling material. This aspect has not been assessed systematically but should be addressed during future work (see Sec. 1.5).

The oldest rocks in the study area are Precambrian quartzites (Figs. 4.2 and 4.3) occurring at Lobo Hill and near South Mountain. These rocks are not encountered along the proposed SSC tunnel alignment.

Pennsylvanian-age rocks (Sandia Formation and Madera Group) occur mainly on the western side of the study area (Fig. 4-3). The underlying Sandia Formation consists of black shale, dark gray limestone, gray-to-brown sandstone, and scattered coal seams. It is 10 to 250 feet thick. The

Table 4-1. Laboratory Test Values for Rock.

LABORATORY DATA--ROCK

Sample No.	Lithology	Unit Age	Density (pcf)	Point Load Strength Index I(s)(50) (MPa)*
SSC R1 MISC	Andesite	Tertiary	160	7.2
SSC R3	Sandstone	Permian	142	4.4
SSC R3 MISC	Sandstone	Triassic	150	6.0
SSC R6	Sandstone	Triassic	132	3.3
SSC R7	Sandstone	Permian	150	8.6
SSC R8	Limestone	Pennsylvanian	168	7.2
SSC R14	Sandstone	Permian	NP	5.8
SSC R16	Limestone	Pennsylvanian	167	5.9
SSC R17	Monzonite	Tertiary	149	6.8
SSC R18	Monzonite	Tertiary	164	6.1
SSC R19	Sandstone	Permian	154	10.7
SSC R20	Monzonite	Tertiary	153	17.4
SSC R21	Limestone	Pennsylvanian	168	6.0
SSC R22	Limestone	Pennsylvanian	NP	4.8
SSC R23	Monzonite	Tertiary	149	2.5
SSC R24	Limestone	Pennsylvanian	164	7.2
SSC R26	Limestone	Permian	172	11.1
SSC R27	Sandstone	Permian	NP	5.2
SSC R28	Sandstone	Triassic	156	5.4
SSC R29	Sandstone	Permian	135	1.8
SSC R30	Limestone	Permian	163	12.4
SSC R32	Schist	Precambrian	161	5.9
SSC R33	Quartzite	Precambrian	165	12.3
SSC R34	Sandstone	Permian	140	3.9
SSC R35	Sandstone	Permian	148	6.4
SSC R36	Conglomerate	Quaternary	NP	2.6
SSC R37	Sandstone	Permian	145	3.3
SSC R38	Sandstone	Permian	157	7.1
SSC R39	Limestone	Pennsylvanian	171	7.0
SSC R40	Conglomerate	Quaternary	NP	1.1

Strength Classification for Rock Materials (after Bieniawski, 1975)

Description	Uniaxial compressive strength (MPa)*	Point-load index (MPa)*
Very high strength	>200	>8
High strength	100-200	4-8
Medium strength	50-100	2-4
Low strength	25-50	1-2
Very low strength	<25	<1

*MPa=Megapascals

AGE (M.Y.)	STRATIGRAPHIC UNITS		THICKNESS, FT.	DESCRIPTION
	QUATERNARY	HOLOCENE	0-450	YOUNGER LAKE, ALLUVIUM & EOLIAN SEDIMENTS
		PLEISTOCENE		LAKE AND ALLUVIAL SEDIMENTS
2	TERTIARY			OLDER ALLUVIUM
				IGNEOUS INTRUSIVES
63	CRETACEOUS		0-4,550	MOSTLY SHALE, SOME SANDSTONE
138	JURASSIC		0-1,245	SANDSTONE, MUDSTONE
205	TRIASSIC		0-1,800	MOSTLY SHALE, SOME SANDSTONE
240	PERMIAN	BERNAL	0-75	SANDSTONE
		SAN ANDRES	0-200	LIMESTONE, SANDSTONE, EVAPORITES
		GLORIETA	0-200	SANDSTONE
		YESO	0-1,000	SANDSTONE, SHALE, LIMESTONE, ANHYDRITE AND GYPSUM
		ABO	0-1,000	RED SHALE, SANDSTONE
290	PENNSYLVANIAN	MADERA Gp	0-2,000	MOSTLY LIMESTONE, SOME SANDSTONE, SHALE
330 / 570	PRECAMBRIAN			SCHIST, QUARTZITE, GNEISS

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Figure 4-2. Stratigraphic column of geologic units present in the northern Estancia Valley.

BEDROCK GEOLOGY MAP

EXPLANATION

- TERTIARY INTRUSIVES
- CRETACEOUS
- JURASSIC
- TRIASSIC
- PERMIAN UNDIVIDED
  - BERNAL Fm.
  - SAN ANDRES Fm.
  - GLORIETA Fm.
  - YESO Fm.
  - ABO Fm.
- PENNSYLVANIAN (MADERA Gp.)
- PRECAMBRIAN

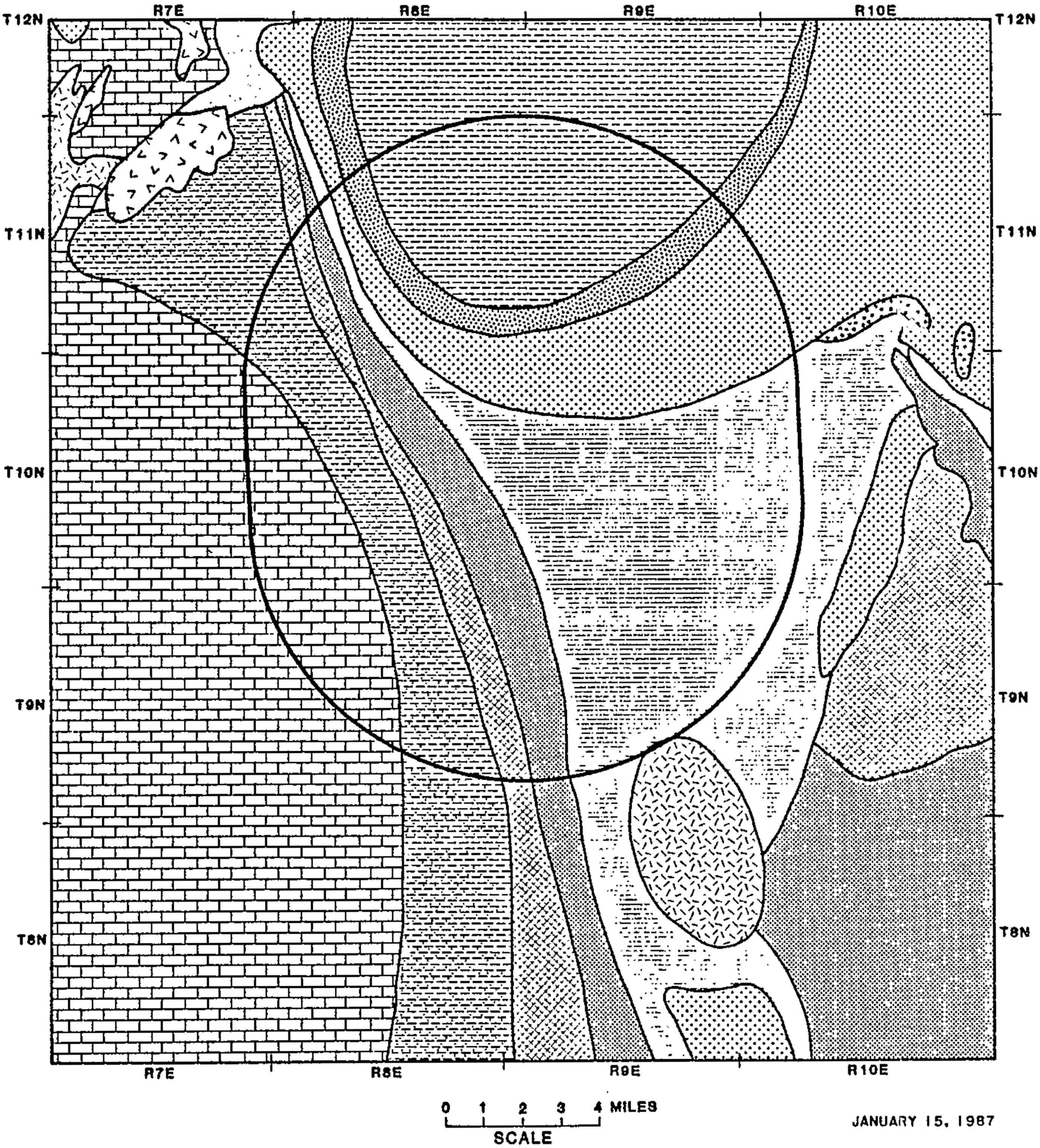

Figure 4-3. Bedrock geology map of rock units below the Cenozoic Valley fill (New Mexico Bureau of Mines and Mineral Resources, 1985).

extent to which it may be encountered by the SSC tunnel has not been assessed because of its great depth of burial within the study area. The overlying Madera Group is divided into two parts. The lower part consists of massive, cherty, gray limestone with interbeds of calcareous gray and black shale. The upper member consists of alternating light-gray cherty limestone, sandy limestone, sandstone, and shale. Locally, small solution features occur throughout Madera Group rocks but large caves and solution subsidence depressions are absent for the most part (Titus, 1973).

Overlying the Madera are Permian-age rocks consisting of interbedded shales, sandstones, and limestones. The Abo Formation, consisting of dark red shale and sandstone, is the oldest and occurs beneath the valley fill in the west-central part of the study area (Fig. 4-3). It is probably less than 1,000 ft thick in the study area.

The overlying Yeso Formation crops out on the eastern side of the study area and underlies basin fill in the eastern two-thirds (Fig. 4-3). To the south of the study area the formation is more than 1,000 ft thick and, in places, contains much gypsum, a soluble mineral. Possible solution subsidence depressions occur at the surface in areas underlain by the Yeso Formation. They appear as broad, shallow, circular-shaped depressions typically a few hundred feet in diameter and less than 15 ft deep. None of these depressions observed in the study area appear to be active. The origin of the possible solution subsidence depressions was not determined. At present, they are not considered a "fatal flaw", but further investigation is recommended (Sec. 1.5) because they could pose a difficulty during tunneling or cause instability problems during operation.

The overlying Glorieta Formation is a thick bedded, clean, well sorted sandstone, 65-125 ft thick in the Sandia Mountains (Kelley and Northrup, 1975) and 150-200 ft thick east of Lobo Hill. It underlies the eastern half of the study area.

The overlying San Andres Formation consists of gray limestone with some interbeds of gypsum and sandstone and is approximately 100 ft thick in the study area. The limestone is also susceptible to development of solution features, and numerous solution subsidence features are associated with this unit. Additional drilling, sampling, and logging are required to determine whether these solution features could cause tunneling difficulties (Sec. 1.5).

Overlying the San Andres Formation are isolated erosional remnants of fine- to medium-grained sandstone and thin-bedded limestone up to 75 ft thick (Bernal Formation; Fig. 4-3). In the study area, these rocks only occur east of the trace of the proposed SSC tunnel.

Triassic-age rocks of the Santa Rosa and Chinle Formations occur on the eastern side of the study area east of the SSC trace and consist of sandstone and mudstone. They occur above the water table and would not be encountered by the proposed SSC tunnel.

Jurassic- and Cretaceous-age rocks occur beneath valley fill in the northern part of the study area and crop out north of the study area (Fig. 4-3). They consist of sandstone, mudstone, and shale. These rocks would likely be encountered along the northwest portion of the SSC tunnel near South Mountain.

Tertiary-age igneous intrusive rocks are present on South Mountain and as dikes north of the study area. These rocks, which locally contain metallic ore deposits, would probably not be encountered by the SSC tunnel. There may be extensions of this rock type under the basin (dikes and sills).

The valley fill material (soil) consists of Tertiary and Quaternary alluvium, wind-blown sand and silt, and lake deposits (Fig. 4-4). Laboratory test values on this material are given in Table 4-2. Clayey lake deposits of early to middle Pleistocene age generally occur below an elevation of 6,330 ft; late Pleistocene lake beds occur below 6,225 ft. The remaining surficial deposits (alluvium and eolian) occur above 6,330 ft elevation or bury and interfinger with lake beds below that elevation. North of I-40 the basin fill is dominantly a mixture of older, partly cemented alluvium and younger, unconsolidated alluvium deposited in draws. Along the SSC tunnel this material would stand well and be easily excavated. South of I-40, the basin fill material is mostly lacustrine in origin and consists of interbedded clay, sand, and silt.

In places, the tunnel would penetrate saturated basin

SURFICIAL GEOLOGY MAP

EXPLANATION

CENOZOIC:
- LAKE DEPOSITS
- MIXED LAKE & ALLUVIUM
- OLDER ALLUVIUM
- INTRUSIVE IGNEOUS ROCKS

CRETACEOUS

TRIASSIC

PERMIAN UNDIVIDED:
- BERNAL Fm.
- SAN ANDRES Fm.
- GLORIETA Fm.
- YESO Fm.

PENNSYLVANIAN (MADERA Gp.)

PRECAMBRIAN

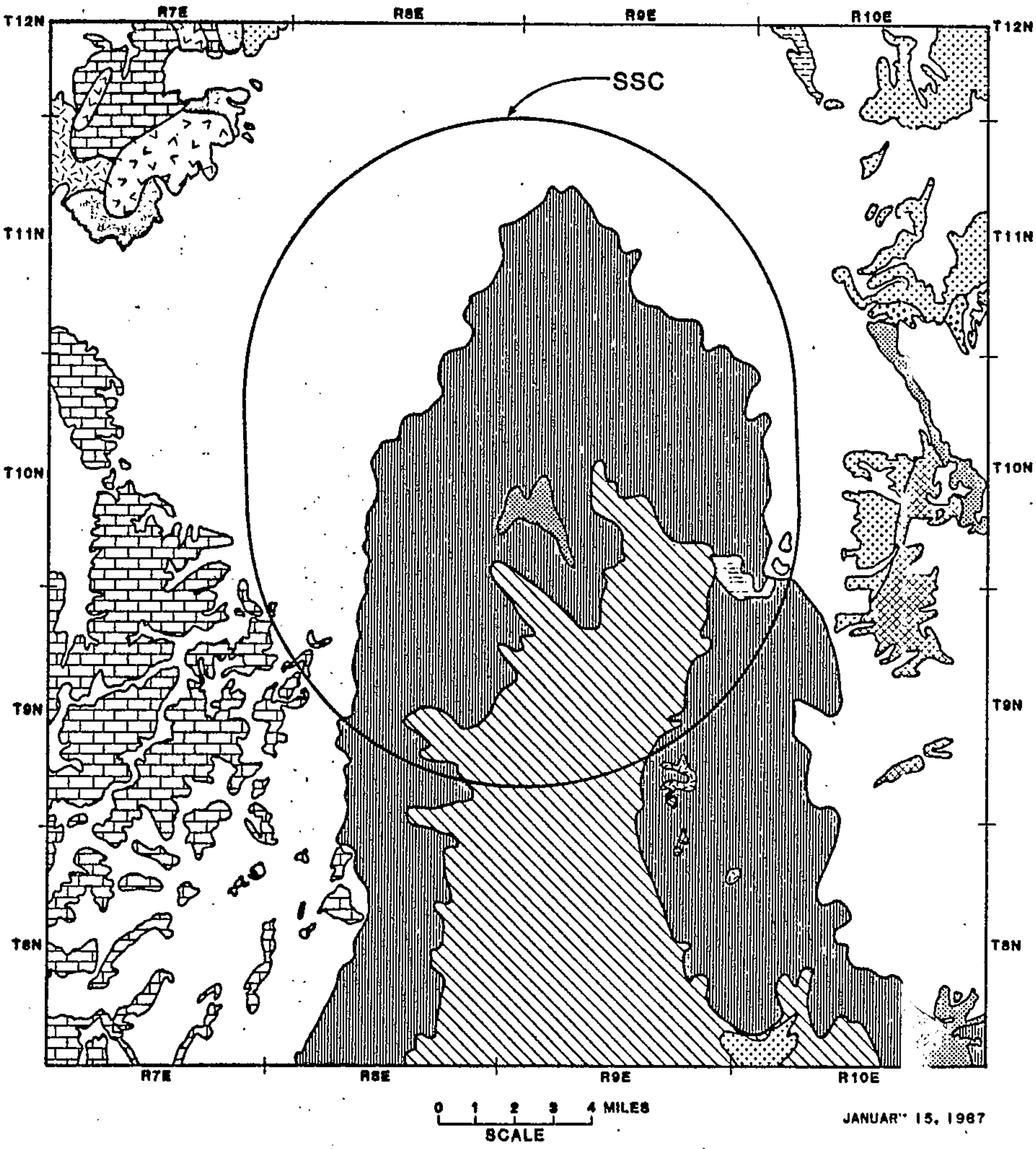

Figure 4-4. Surficial geology map of the northern Estancia Valley.

Table 4-2. Laboratory Test Values for Soil (1 of 4).

LABORATORY DATA--SOIL

Sample/ Test Hole No.	Depth of Sample (ft.)	Sample Type D=Disturbed	Density (pcf) Wet	Density (pcf) Dry	Moisture Content (%)	Atterberg Limits LL	Atterberg Limits PI	Sieve Analysis (% Passing) 1/2"	3/8"	1/4"	No. 4	No. 20	No. 40	No. 60	No. 80	No. 100	No. 140	No. 200	USCS Soil Description GROUP SYMBOL	GROUP NAME
SSC S12	2	D																		
SSC S13	2	D																		
SSC S15	2	D																		
SSC S18	2	D																		
DH1	2	D			6	26	7													
DH1	5	D			6															
DH1	8	D			2															
DH1	14	D			10	26	7													
DH2	4-5.5	D			7	21	NP	100	100	100	100	100	95	82	71	63	40	21	SM	silty sand
DH2	9-10.5	D			16	53	31	100	100	100	100	100	100	100	100	100	99	97	CH	fat clay
DH2	19-20.5	D			12	25	6	100	100	100	100	96	83	74	68	63	50	36	SM-SC	silty sand-clayey sand
DH2	29-30.5	D			9	30	11	100	100	100	100	98	90	83	77	72	52	29	SC	clayey sand
DH2	39-40.5	D			13	28	12	100	100	100	100	97	95	91	88	83	74	59	CL	Lean clay
DH3	9-10.5	D			12	38	NP	100	100	100	100	91	75	63	56	52	43	33	SM	silty sand
DH3	19	D			4			100	99	86	76	38	22	12	9	4	1	0		
DH3	30	D			9	29	14													
DH3	45	D			12			100	100	100	100	78	67	60	55	52	44	34		
DH4	4-5	D			10	26	9	100	100	99	99	95	83	72	66	60	46	30	SC	clayey sand
DH4	9-10	D			11	23	NP	100	100	100	100	99	93	83	78	70	53	28	SM	silty sand
DH4	19-20	D			7	25	4	100	100	100	100	97	90	83	77	72	55	31	SM-SC	silty sand-clayey sand
DH4	29-30	D			13	32	15	100	100	100	100	97	88	78	72	67	56	40	SC	clayey sand
DH5	4-5	D			10			100	100	100	100	95	84	75	68	60	40	23		
DH5	9-10	D			8			100	100	100	100	97	89	81	76	72	59	40		
DH6	4-5	D			7			100	100	98	97	90	83	78	70	64	47	30		
DH6	9-9.5	D			12															
DH6	19-19.25	D			16															
DH7	4-5	D			6	23	4	100	100	98	96	91	83	74	67	61	44	27	SM-SC	silty sand-clayey sand
DH7	9-10	D			5	22	1	100	100	100	100	97	91	84	78	72	51	27	SM	silty sand
DH7	19-20	D			7	29	6	100	100	100	100	98	91	77	69	63	53	39	SM	silty sand
DH7	29-30	D			7	20	2	100	100	100	99	88	76	65	56	49	34	21	SM	silty sand
DH8	4-5	D			5			100	100	100	100	99	92	82	76	71	55	34		
DH8	9-10	D			7			100	100	100	100	100	96	90	86	83	75	55		
DH8	19-20	D			5			100	100	100	100	100	98	91	84	78	65	46		
DH8	29-30	D			2															
DH9	4-5	D			13	24	4	100	100	100	100	100	99	96	94	91	78	57	CL-ML	silty clay
DH9	9-10	D			10	25	6	100	100	100	100	99	93	87	82	77	59	35	SM-SC	silty sand-clayey sand
DH9	19-20	D			19	42	18	100	100	100	100	99	92	83	78	72	62	47	SC	clayey sand
DH9	29-30	D			14	36	13	100	100	100	100	100	99	95	90	86	83	75	CL	lean clay
DH10	4-5	D			13	20	NP	100	100	100	100	99	95	88	81	75	57	33	SM	silty sand
DH10	9-10	D			6	NP	NP	100	100	99	95	70	43	29	22	18	12	7	SW-SM	well graded sand with silt
DH10	19-20	D			15	20	4	100	100	100	100	99	99	92	83	78	71	58	CL-ML	silty clay
DH10	29-30	D			13	21	9	100	100	100	100	100	100	100	97	95	83	63	CL	lean clay
DH11	4.5-5	D			7	23	NP													
DH11	9-9.5	D			7	24	3													
DH11	19-20.5	D			11	26	4													
DH11	29-29.5	D			12	35	12													
DH12	4-5.5	D			7	25	5	100	100	100	100	98	88	78	72	68	54	36	SM-SC	silty sand-clayey sand
DH12	9-10.5	D			6	24	6	100	100	100	100	99	92	81	73	68	55	40	SM-SC	silty sand-clayey sand
DH12	19-20.5	D			8	29	10	100	100	100	100	99	91	82	75	70	57	40	SC	clayey sand
DH13	4-5.5	D			5															
DH13	9-10.5	D			11															
DH13	19-20.5	D			7															
DH 14	4-5.5	D			11															
DH 14	9-10.5	D			10															
DH 14	19-19.5	D			9															
DH15	4-5	D			13			100	100	100	100	89	75	66	60	56	46	33		
DH15	4.5-5.5	D			13															
DH15	9-9.5	D			11															
DH15	19-20.5	D			13															
DH16	4-4.5	D			7															
DH16	9-9'10"	D			12															

Table 4-2. Cont. (2 of 4)

LABORATORY DATA--SOIL

Sample/ Test Hole No.	Depth of Sample (ft.)	Sample Type D=Disturbed	Density (pcf) Wet	Dry	Moisture Content (%)	Atterberg Limits LL	PI	Sieve Analysis (% Passing) No. 1/2"	No. 3/8"	No. 1/4"	No. 4	No. 20	No. 40	No. 60	No. 80	No. 100	No. 140	No. 200	USCS Soil Description GROUP SYMBOL	GROUP NAME
DH17	4-4.5	D			15															
DH17	4.5-5.5	D			6															
DH17	9-10.5	D			13															
DH17	19-19.25	D			13			100	100	100	100	96	86	77	72	68	61	51		
DH17	19.25-20.5	D			40															
DH17	29-30.5	D			14			100	100	100	100	99	94	89	85	82	70	51		
DH17	"TIP"	D			17			100	100	100	100	89	77	65	58	53	44	32		
DH18	4-5.5	D			7															
DH18	9-9.75	D			11															
DH18	9.75-10.5	D			26															
DH18	19-20	D			4															
DH18	20-20.5	D			10															
DH18	29-30	D			22															
DH 19	4-4.5	D			9															
DH 19	9-9.5	D			11															
DH 19	19.5	D			15															
DH20	0-1.5	D			16															
DH20	1.5-3	D			8															
DH20	3-4.5	D			14															
DH20	4.5-6	D			15															
DH20	6-7.5	D			15															
DH20	7.5-9	D			17															
DH20	9-10.5	D			18															
DH20	10.5-12	D			16															
DH20	12-13.5	D			11															
DH20	13.5-15	D			16															
DH20	15-16.5	D			26															
DH20	16.5-18	D			12															
DH20	18-19.5	D			30															
DH20	19.5-21	D			21															
DH20	21-22.5	D			29															
DH20	29-30.5	D			15															
DH 21	4-5.5	D			5															
DH 21	9-10.5	D			7															
DH 21	19-20.5	D			5															
DH 21	24	D			0.5															
DH 21	29-30.5	D			9															
DH22	4-5.5	D			11															
DH22	9-10.5	D			9															
DH22	19-20.5	D			5															
DH22	29-30.5	D			7															
DH 23	4-5.5	D			12	44	24													
DH 23	9-10.5	D			7	26	8													
DH 23	19-20.5	D			22	47	24													
DH 23	29-30.5	D			18	30	19													
DH 24	4-5.5	D			9															
DH 24	9-10.5	D			7															
DH 24	19-20.5	D			13															
DH 24	29-30.5	D			22															
DH 25	4-5.5	D			4															
DH 25	9-9.5	D			4															
DH 25	9.5-10.5	D			9															
DH 25	19-19.5	D			8															
DH 25	20-20.5	D			8															
DH 25	29-29.5	D			24															
DH 25	29.5-30.5	D			7															
DH 26	4-5.5	D			8															
DH 26	9-9.5	D			4															
DH 26	9.5-10.5	D			10															
DH 26	19-20.5	D			16															
DH 26	29-30.5	D			21															
DH1 1	4	D			9	33	10													
DH1 2	6.6	D			6	NP	NP													
DH1 3	8.2	D			10	27	5													
DH1 4	9.4	D			9	26	4													

Table 4-2. Cont. (3 of 4)

LABORATORY DATA--SOIL

Sample/ Test Hole No.	Depth of Sample (ft.)	Sample Type D=Disturbed	Density (pcf) Wet	Dry	Moisture Content (%)	Atterberg Limits LL	PI	Sieve Analysis (% Passing) No. 1/2"	No. 3/8"	No. 1/4"	No. 4	No. 20	No. 40	No. 60	No. 80	No. 100	No. 140	No. 200	USCS Soil Description GROUP SYMBOL	GROUP NAME
BH2 1	1.2	D			19	26	6													
BH2 2	3	D			11	37	13													
BH2 3	5.5	D			7	38	9													
BH2 4	6.9	D			10	30	8													
BH2 5	7	D			10	26	6													
BH2 6	11.5	D			7	21	NP													
BH2 7	5.5	D			9	29	7													
BH3 1	0.4	D			10	20	NP													
BH3 2	1	D			12	19	NP													
BH3 3	3	D			10	19	NP													
BH3 4	5	D			3	NP	NP													
BH3 5	7.8	D			13	34	19													
BH4 1	1	D			12	NP	NP													
BH4 2	3	D			3	NP	NP													
BH4 3	4.4	D			5	NP	NP													
BH4 4	4.6	D			6	NP	NP													
BH4 5	5	D			12															
BH4 6	6.6	D			12	24	8													
BH5 1	1	D			21	26	6													
BH5 3	4	D			11	21	4													
BH5 4	6.8	D			8	23	3													
BH6 1	0.2	D			21			100	100	100	100	99	98	96	94	87	43	19		
BH6 2	1.8	D			12			100	100	100	100	99	92	84	81	79	75	65		
BH6 3	3.2	D			5	24	NP	100	100	100	100	95	90	87	84	82	74	48	SM	silty sand
BH6 4	4.6	D			4															
BH6 5	5.4	D			10															
BH6 6	6.5	D			4															
BH6 7	7.3	D			11															
BH6 8	7.9	D			8															
BH6 9	8.4	D			15															
BH6 10	9	D			5															
BH7 1	0.4	D			12															
BH7 2	2.9	D			17	39	16													
BH7 3	3.9	D			6	26	NP													
BH7 4	5.2	D			8															
BH7 5	6.3	D			8	27	NP													
BH7 6	6.7	D			14															
BH7 7	7.3	D			3	23	NP													
BH7 8	7.7	D			21	21	NP													
BH7 9	8.1	D			8	22	NP													
BH8 1	1.2	D			20	27	5													
BH8 2	4.6	D			16	33	8													
BH8 3	6	D			16	38	18													
BH8 4	8.6	D			12	31	8													
BH9 1	0.6	D			60															
BH9 2	2.4	D			6	33	4													
BH9 3	7.2	D			2															
BH9 4	9.2	D			9	30	4													
SL1 3+00W	2	D				29	7	100	100	100	100	96	92	86	81	78	70	57	ML	sandy silt
SL1 9+00W	2	D				24	5	100	100	100	99	93	87	80	74	69	55	35	SM-SC	silty sand-clayey sand
SL1 15+00W	2	D				38	16	100	100	100	100	93	90	87	85	85	83	81	CL	lean clay with sand
SL1 21+00W	2	D				19	3	100	99	99	99	85	76	66	60	54	41	24	SM	silty sand
SL1 27+00W	2	D				25	5	100	100	99	99	98	96	94	92	91	86	74	CL-ML	silty clay with sand
SL1 33+00W	2	D				25	5	100	100	99	99	83	72	66	61	49	37	34	SM-SC	silty sand-clayey sand
SL1 39+00W	2	D				NP	NP	65	65	64	64	62	61	60	60	59	58	57	ML	gravelly silt
SL1 45+00W	2	D				NP	NP	80	80	79	79	77	76	75	74	73	70	68	ML	silt with gravel
SL1 51+00W	2	D				38	9	100	100	100	100	94	90	85	80	77	70	65	ML	sandy silt
SL1 57+00W	2	D				32	7	95	91	84	84	61	55	52	50	49	44	42	ML	sandy silt
SL1 63+00W	2	D				27	5	100	100	100	100	69	51	41	37	36	34	30	SM-SC	silty sand-clayey sand
SL1 69+00W	2	D				24	2	95	90	80	80	45	33	26	25	24	15	13	SM	silty sand
SL1 75+00W	2	D				24	5	98	97	92	92	73	56	42	38	36	33	28	SM-SC	silty sand-clayey sand
SL1 81+00W	2	D						100	100	100	100	100	100	99	98	92	58	39	NP	NP
SL1 87+00W	2	D				32	5	100	100	100	100	99	98	97	97	95	91	85	ML	silt
SL1 90+00W	2	D				35	12	100	100	100	100	100	99	98	97	96	91	77	CL	clay with sand
SL1 96+00W	2	D				32	11	100	100	100	100	97	84	74	69	65	54	41	SC	clayey sand
SL1 102+00W	2	D				39	17	100	100	100	100	67	53	44	39	36	29	21	SC	clayey sand
SL1 108+00W	2	D				32	12	100	100	100	100	97	96	94	90	89	81	64	CL	sandy lean clay
SL1 114+00W	2	D				32	10	100	99	97	97	84	75	68	63	59	48	34	SC	clayey sand

Table 4-2. Cont. (4 of 4)

LABORATORY DATA--SOIL

Sample/ Test Hole No.	Depth of Sample (ft.)	Sample Type D=Disturbed	Density (pcf) Wet	Density (pcf) Dry	Moisture Content (%)	Atterberg Limits LL	Atterberg Limits PI	Sieve Analysis (% Passing) No. 1/2"	No. 3/8"	No. 1/4"	No. 4	No. 20	No. 40	No. 60	No. 80	No. 100	No. 140	No. 200	USCS Soil Description GROUP SYMBOL	GROUP NAME
SL2 0+00	2	D				32	8	94	88	81	81	68	62	56	51	49	39	24	SM	silty sand with gravel
SL2 9+00N	2	D				23	2	100	99	96	96	79	65	48	42	41	37	28	SM	silty sand
SL2 18+00N	2	D				27	5	93	88	77	77	59	52	39	37	35	30	20	SM	silty sand with gravel
SL2 27+00N	2	D				23	3	100	94	94	92	86	71	46	44	43	39	31	SM	silty sand
SL2 36+00N	2	D				NP	NP	99	97	94	94	89	87	82	78	74	60	52	SM	silty sand
SL2 42+00N	2	D				NP	NP	100	99	98	98	93	87	81	77	74	59	36	SM	silty sand
SL2 9+00S	2	D				28	5	94	93	88	85	77	72	64	58	52	40	26	SM-SC	silty sand-clayey sand
SL2 18+00S	2	D				NP	NP	77	75	69	69	63	61	57	52	47	34	21	SM	silty sand with gravel
SL2 27+00S	2	D				NP	NP	96	92	89	89	82	81	78	74	70	54	33	SM	silty sand
SL2 36+00S	2	D				NP	NP	97	96	92	92	89	87	85	80	76	51	22	SM	silty sand
SL2 45+00S	2	D				NP	NP	86	84	80	80	73	71	68	65	61	45	22	SM	silty sand with gravel
SL3 0+00	2	D				NP	NP	100	100	100	100	99	98	91	83	77	56	33	SM	silty sand
SL3 9+00E	2	D				22	3													
SL3 15+00E	2	D				NP	NP	100	100	99	98	96	93	82	71	63	42	25	SM	silty sand
SL3 24+00E	2	D				20	NP	100	100	99	99	97	90	77	68	61	44	28	SM	silty sand
SL3 36+00E	2	D				19	NP	100	98	98	97	93	84	73	65	59	43	26	SM	silty sand
SL3 45+00E	2	D				26	7	100	100	100	100	99	94	83	74	68	56	45	SM-SC	silty sand-clayey sand
SL3 54+00E	2	D				NP	NP	100	100	100	100	100	97	85	74	67	47	26	SM	silty sand
SL3 63+00E	2	D				NP	NP	100	100	100	100	100	97	87	77	68	42	23	SM	silty sand
SL3 72+00E	2	D				28	8	100	100	100	100	100	98	90	82	76	58	40	SC	clayey sand
SL3 79+18E	2	D				23	5	100	100	100	100	98	91	77	68	62	45	28	SM-SC	silty sand-clayey sand

fill and dewatering would possibly be required. A concern is that continued ground water withdrawal, which locally has exceeded 40 feet of drawdown, could cause ground subsidence. Such subsidence has been noted in the Deming, New Mexico, and central Arizona regions. It is recommended that assessments of ground subsidence potential due to ground-water withdrawal be conducted (see Sec. 1.5).

4.3 Hydrogeology

Hydrogeologic or geohydrologic assessments were not conducted for this study. The following discussion is modified from NMBMMR (1985).

Ground water flows from upland recharge areas on the Estancia Valley margins toward lower discharge points associated with playas in the southeastern part of the valley. Pumpage and zones of higher conductivity complicate this otherwise simple flow system. The floor of the valley is covered by fill of Tertiary and Quaternary age. Underlying this fill is a sequence of gently eastward-dipping older bedrock units. Each of these units serves as a principal aquifer for some part of the valley. Aquifer characteristics are summarized in Table 4-3. The elevation of the water table in the valley is shown in Figure 4-5.

Heterogeneous valley fill is the principal aquifer in the main part of the Estancia Valley (Smith, 1957). Titus (1980) reported that near Edgewood the water table was near the base of the valley fill or in the underlying Paleozoic bedrock. In response to irrigation pumpage, ground-water

Table 4-3. Summary of aquifer characteristics, Estancia Valley.

Aquifer	Lithology	Thickness (ft)	Depth to water (ft)	Maximum Yield (gpm)	Total Dissolved Solids (ppm)	Data Sources*
Valley fill	gravel, sand, clay	0 - 405	0 - 250	2,300	207 - 6,170	1,2
Glorieta Sandstone	sandstone	0 - 200	25 - 200	>3,000	592 - 5,270	1
Yeso Formation	sandstone, shale, limestone, anhydrite	380 - 700	20 - 625	3,000	220 - 12,300	1
Abo Formation	sandstone,	300 - 1,000	5 - 900	10	258 - 504	1
Madera Group	limestone, shale, siltstone, conglomerate, sandstone	0 - 2,700	5 - 1,100	1,100	<459	1,2,3,4

* Data Sources: 1) Smith (1957); 2) Mourant (1980); 3) Jenkins (1982); and 4) Titus (1980).

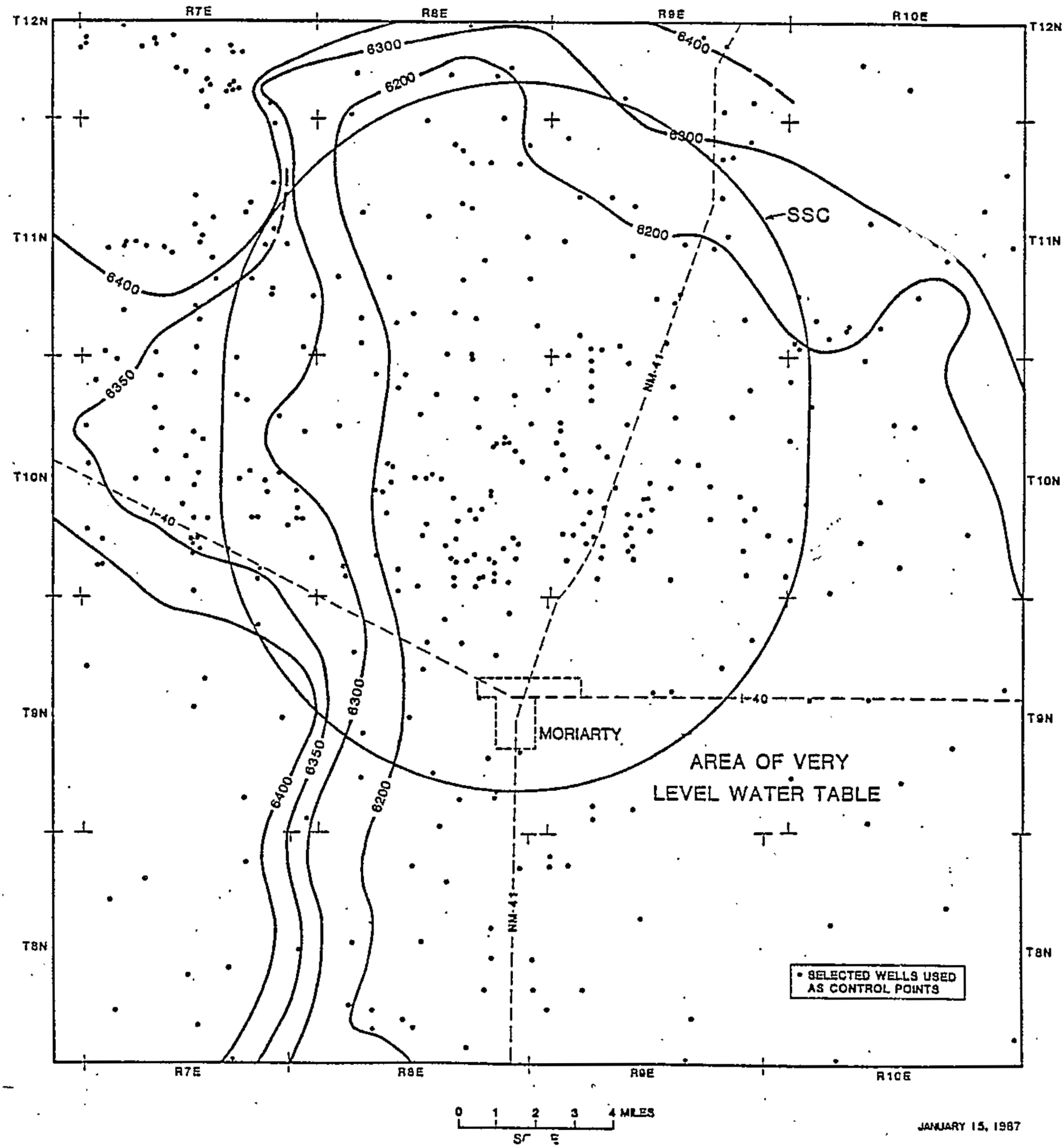

Figure 4-5. Elevation of the water table in the northern Estancia Valley (Mourant, 1980; Smith, 1957).

levels have declined. By 1971, declines of as much as 40 ft were observed in the vicinity of the Torrance-Santa Fe County line north of Moriarty (Bureau of Reclamation, 1976). The average yield of a good valley-fill well 30 years ago was 1,200 gpm (Smith, 1957). Quality of water from the valley fill varies with location. Salinity increases along flow lines. In places, the water is satisfactory for all uses; in others it is suitable only for use by livestock (Smith, 1957).

4.4 Seismicity

Seismicity in New Mexico is low in comparison to some other western states such as California, Nevada, and Utah. According to Sanford et al. (1981), seismicity in New Mexico is controlled largely by local geologic conditions such as injection of magma into shallower regions of the earth's crust (Socorro area) or by man-caused hydrocarbon recovery (southeastern New Mexico). Some seismic activity can be correlated to major tectonic structures. Statewide, New Mexico experiences approximtely one magnitude 5.1 event per 100 years (Sanford, 1983).

Within the immediate area of the SSC site, the largest historic seismic event was a modified Mercalli intensity VII to VIII event near Cerrillos in 1918 (Fig. 4-6). Cerrillos is approximately 35 miles north of Moriarty. Earthquakes of this magnitude are capable of damaging weakly constructed building walls (e.g., adobe) or toppling chimneys. Olsen (1979) estimated the 1918 Cerrillos earthquake caused

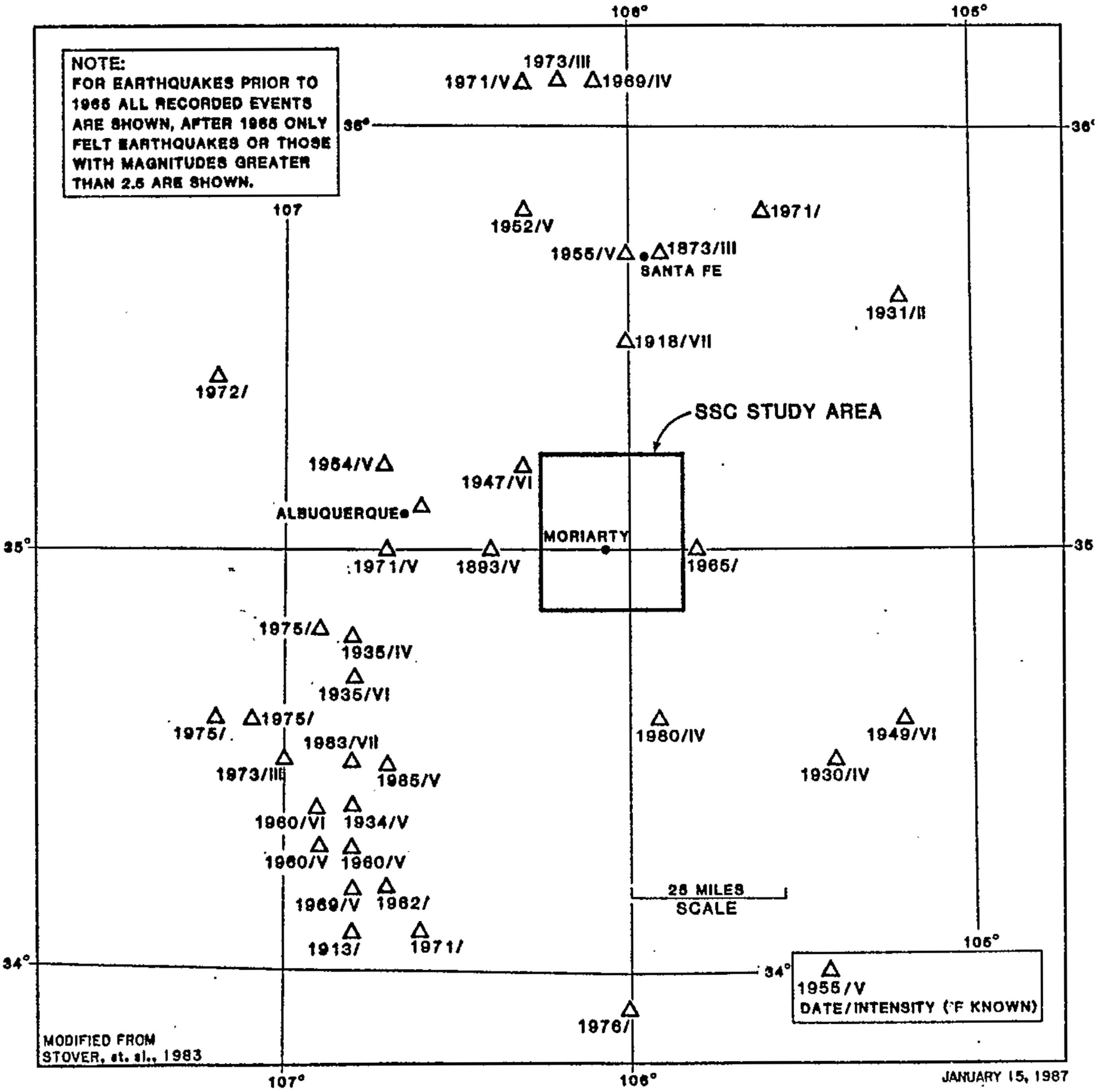

Figure 4-6. Seismicity map of north-central New Mexico showing earthquakes within 100 miles of Moriarty. Some low-magnitude events not shown. See figure 4-7 for location of low-magnitude events in the SSC study area.

shaking in Moriarty at a level of about intensity III-V (i.e., some dishes were broken, some plaster cracked, pendulum clocks stopped).

Within the SSC study area, historic seismic activity is very low. Only two events of less than Richter magnitude 1.6 have been instrumentally recorded (Fig. 4-7).

Evidence that would have indicated possibly stronger prehistoric events would be active faults or liquifaction features. No geologic evidence of stronger events was observed during this study. It is concluded that seismicity is very low in the SSC site and potential for generation of significant earthquake events within the site during operation of the SSC facility (assumed to be less than 50 years) is nil. Large earthquakes (at a distance from the study area) could occur and cause some disruption of SSC operation. This potential has not been assessed.

5.0 UTILITIES AND WASTE DISPOSAL

Utility availability, capacity, and costs are crucial to SSC site suitability. The major utility needs are electrical power grids, water, fuel, proximity of solid and sewage waste facilities, and telecommunications capacity. The following sections document the existing utilities and their capacities.

5.1 Electrical Power

The SSC power requirements range from 230 kv to 500 kv. Electrical power is a requirement in the SSC tunnel, experimental halls, and scientific complexes.

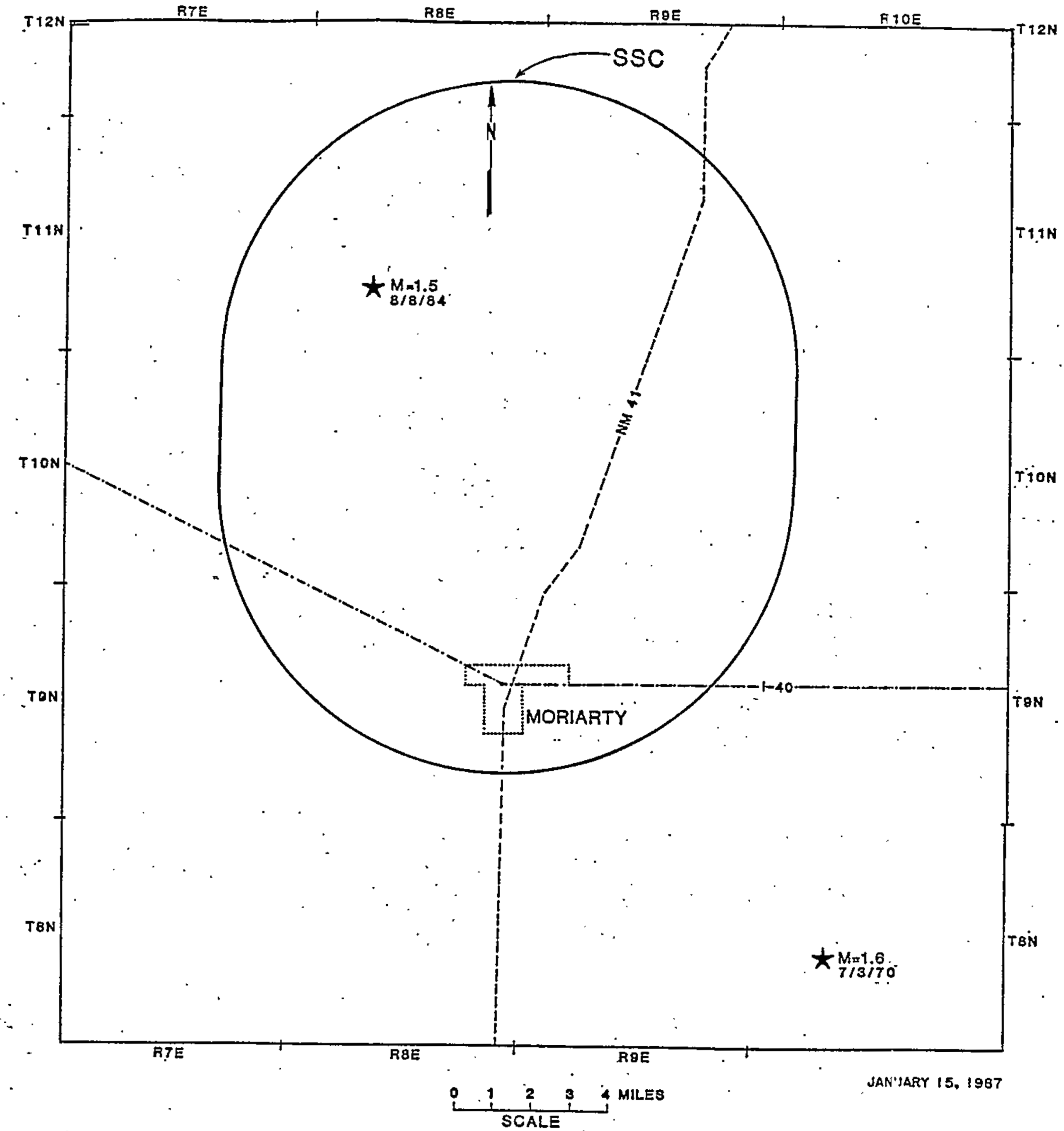

Figure 4-7. Seismic activity within the SSC study area 1965-1985 (pers. comm. A. Sanford, 1986).

Two transmission lines cross the proposed trace of the SSC tunnel (Fig. 5-1). The Central New Mexico Electric Cooperative (CNMEC), based in Mountainair, has a 115 kv transmission line that runs north-south and feeds into Moriarty. In the northern part of the study area the Public Service Company of New Mexico (PNM) has a 345 kv transmission line that runs northwest-southeast. This line is 80 percent uncommitted and can tie in to the site to provide the main power needs (pers. comm., Scott Berger, PNM, 1986). Power costs for single users average four cents per kilowatt hour (kwh). The cost decreases for major users.

5.2 Water

The SSC water requirements are for cooling and for potable water. The total water demands will be approximately 2,700 gallons/minute (gpm). The majority of the water will be used for cooling and will need to be industrial quality. A smaller amount of water will be used as potable drinking water that needs to comply with the National Interim Primary Drinking Water Regulations and State Water Quality Standards (SSC Central Design Group, 1985).

No permanent surface water is located within the study area; private wells for domestic use and irrigation provide the majority of water in the study area except in Moriarty, which has a public water system. Water well depth, aquifer characteristics, water quality, and flow rates vary widely

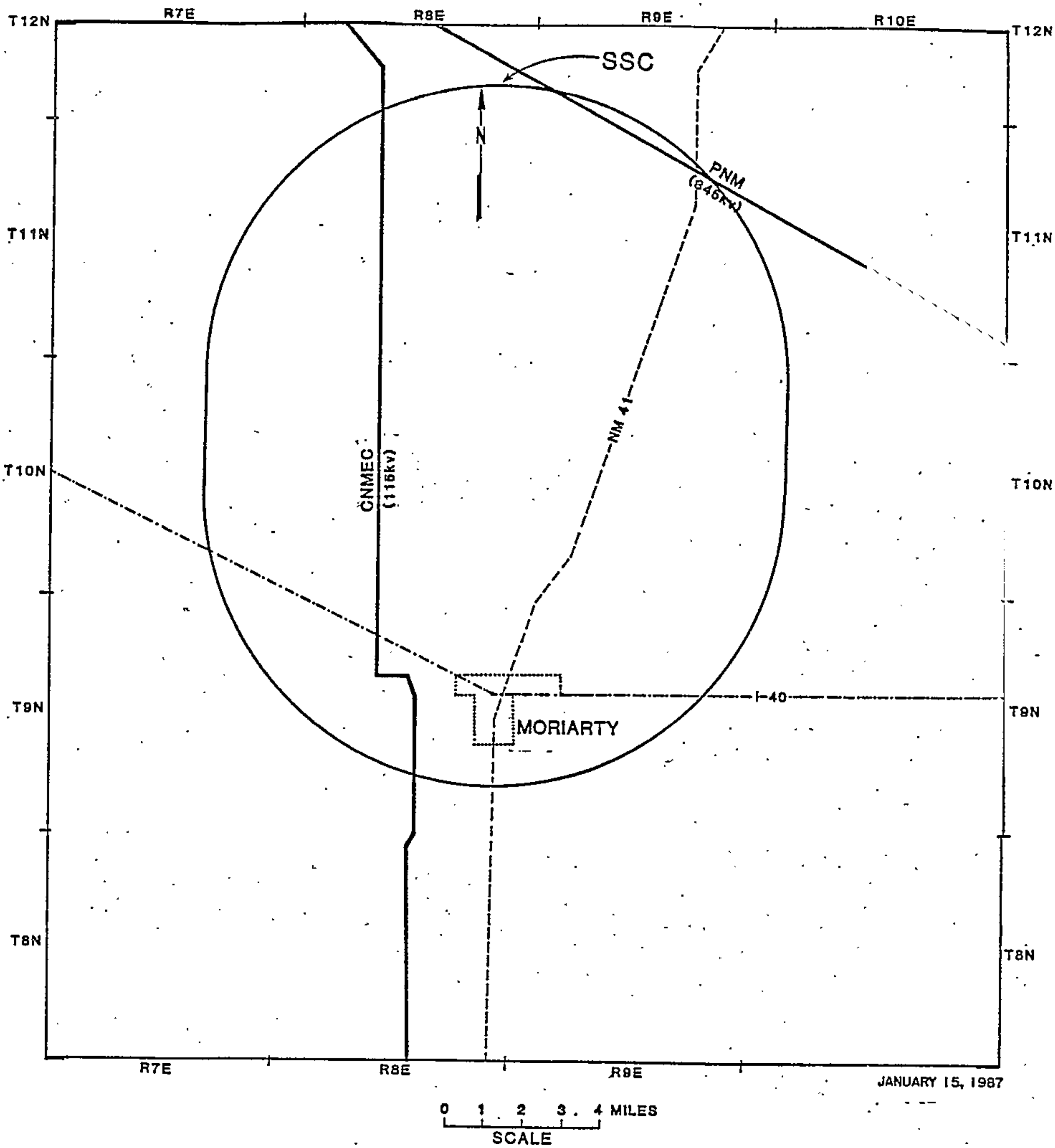

Figure 5-1. Transmission lines crossing the northern Estancia Valley (pers. comm., S. Berger Public Service Company of New Mexico (PNM), 1986; B. Hibner, Central New Mexico Electric Cooperative (CNMEC), 1986).

throughout the study area. The average depth to water is 150 ft. Yields range from 1,500 gpm to more than 3,000 gpm (NMBMMR, 1985). Water quality decreases in the eastern part of the study area where salinities are higher.

The water requirements for the SSC can be easily met by a few selectively placed water wells. Permits from the State Engineer Office are required prior to drilling new water wells. Potable water can also be supplied by the existing public water system located in Moriarty.

5.3 Fuel

The winter heating needs of the SSC would be low in New Mexico compared to most other states. In New Mexico approximately 55,000 MBtu per hour will be needed. There are four major fuel pipelines crossing the study area (Fig. 5.2).

The Estancia Valley is currently served by the EMW Gas Association which supplies natural gas (from the El Paso Natural Gas Company) at a rate of 15,000 cubic feet per hour (CFH). Cost at present is \$2.99/million feet^3 (MCF) for quantities over 40,000 MCF. At present, the EMW Gas Association cannot provide the volume of natural gas necessary for SSC operation, but they expressed a willingness to expand their capacity to meet SSC requirements (pers. comm., Jerry Sanchez, EMW Gas Association, 1986).

Other possible options for providing SSC fuel requirements include: tie-ins from the existing pipelines,

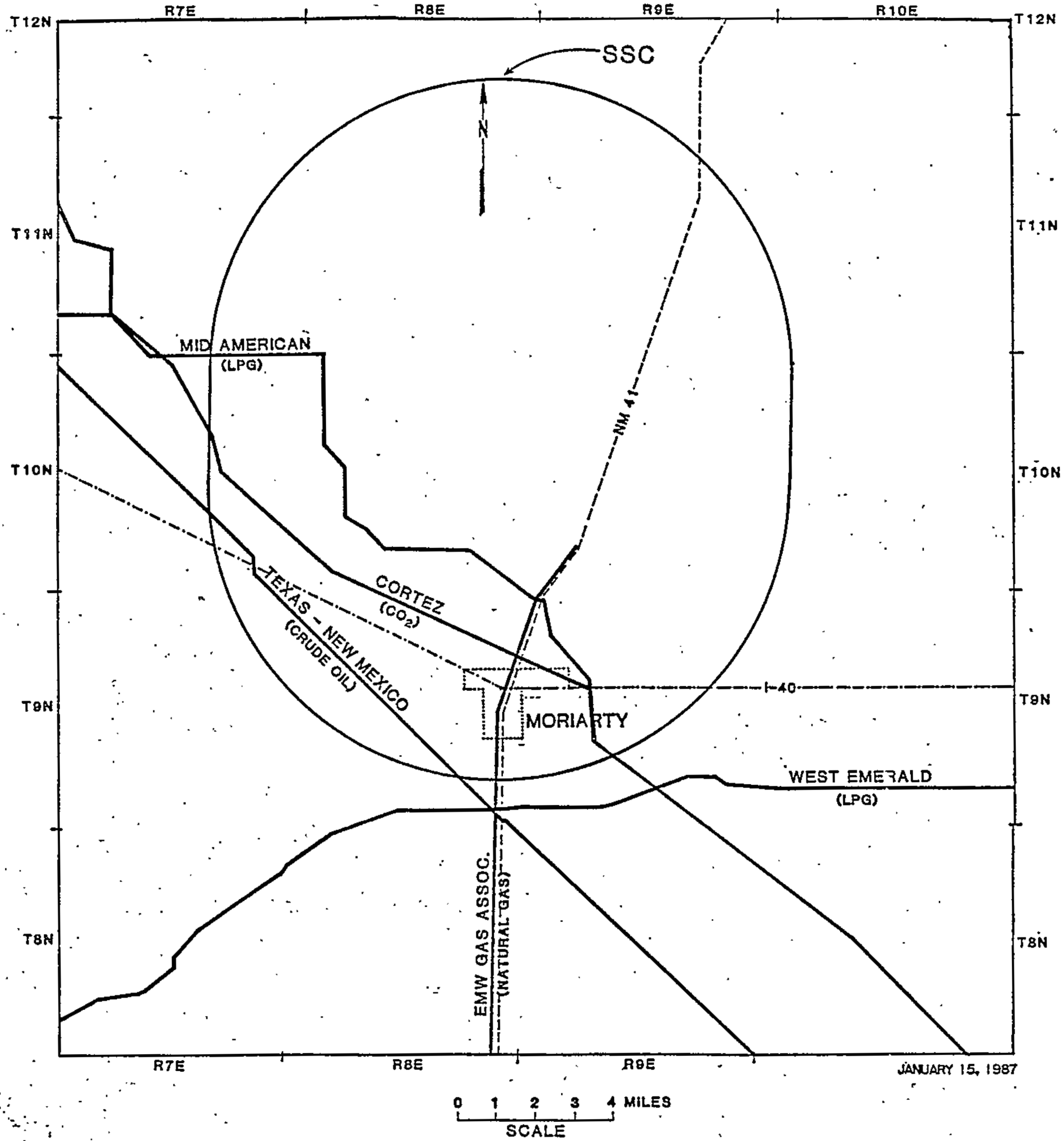

Figure 5-2. Major pipelines crossing the northern Estancia Valley (pers. comm.) J. Sanchez, E.M.W. Gas Association, 1986; (pers. comm.) B. Lednecky, Texas-New Mexico Pipeline Company, 1986; D. Hickey, West Emerald Pipeline Corporation, 1986; (pers. comm.) C.D. Simons, Shell Pipeline Corporation (CORTEZ) 1986; U.S. Geological Survey, 1956).

expansion of present facilities, and development of solar energy.

5.4 Waste disposal

Both liquid and solid wastes would be generated during operation of the SSC. Liquid wastes are likely to be disposed of at an on-site sewage-treatment facility. Currently, solid wastes are disposed of in land fills and the capacity of these land fills has not been assessed. Other possible disposal methods include: on-site landfill disposal, recycling, incineration, or shipment to regional landfills.

5.5 Telecommunications

The telecommunications required to support the operation of the SSC include a Private Automatic Branch Exchange (PABX) with a capacity of 4,000 lines and 300 to 400 trunks (SSC Central Design Group, 1985).

Currently, the telecommunications needs in the study area are serviced by the Mountain Bell Telephone Company (Fig. 5-3). To link the SSC to the existing telecommunications network, new trunks and lines would need to be installed. Mountain Bell has expressed a willingness to provide service by installing the necessary lines (pers. comm., Dan Willis, Albuquerque Metro's Engineering, Planning, and Records Department, Mountain Bell, 1986).

6.0 REGIONAL CONDITIONS

The microdiameter (less than 0.001 inch) of the colliding

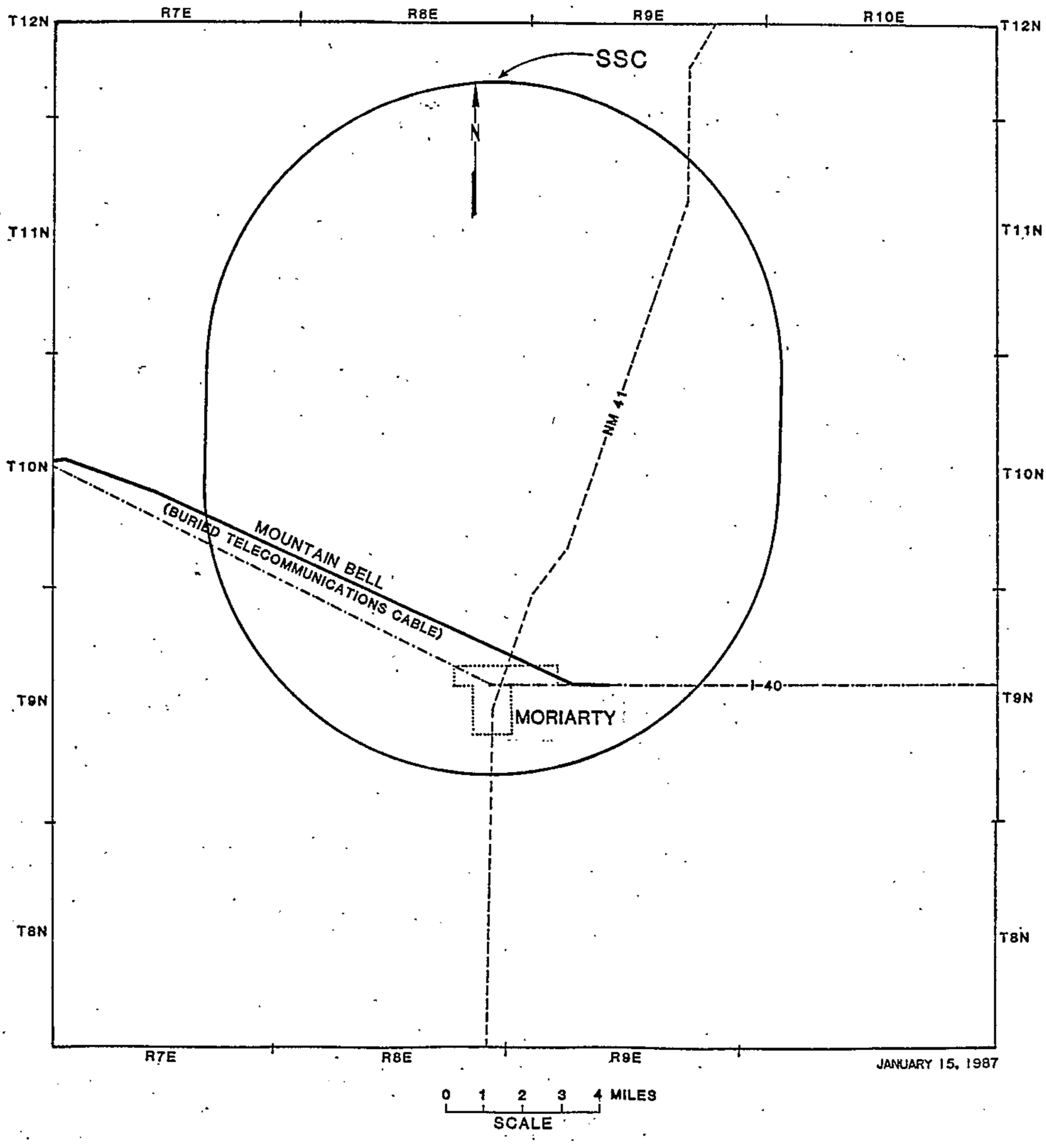

Figure 5-3. Telecommunications cable in the northern Estancia Valley (U.S. Geological Survey, 1956).

beams in the SSC requires stability of the operating systems. Any noise or vibration could be disruptive and should be documented. The SSC collider is most sensitive to disturbances in the frequency range of three hertz.

6.1 Man-made disturbances

A three hertz signal could be produced by heavy truck traffic along I-40 (pers. comm., Allen Sanford, New Mexico Tech, 1986). Although vibrations from traffic would likely be attenuated, all possible sources within this range need to be documented. There are no railroads or heavy machinery operations in the study area. The frequency range from blasting operations at nearby mines needs to be assessed.

6.2 Climate

The local climate will have a direct effect on SSC operation, cost and efficiency. Documentation of climatic conditions is necessary for determining schedule and cost of construction as well as long-term operational costs. A seasonal mean average temperature of 35 °F or greater in winter and 80 °F or less in summer is desirable (SSC Central Design Group, 1985).

The northern Estancia Valley is located east and south of major mountain ranges. The climate is classified as semiarid in the valley and subhumid along the western highlands (Soil Conservation Service, 1970, 1975, 1977). In the valley, summers are warm and dry with daytime temperatures exceeding 90 °F an average of 30 days/year (Table 6-1); temperatures above 100 °F are rare; winters are cold, clear, and sunny causing considerable daytime warming. The clear winter weather causes nighttime cooling with minimum temperatures below freezing from mid-October to mid-April. In the study area, the mean average winter temperature is 40 °F and the mean average summer temperature is 66 °F.

The annual precipitation in the valley is approximately 12 inches (Table 6-2). Seventy percent of the year's precipitation occurs between May and October. The summer precipitation occurs as brief thunder showers. Winter precipitation (snow) falls mainly in the higher elevations; therefore, winters are normally dry in the valley. Snowfall averages approximately 20 inches/year with snow staying on the ground for no more than a few days. The average relative humidity ranges from 50 percent in the summer to 30 percent in the winter.

The average wind velocity is 7.1 miles per hour (blowing from the west); the windiest season is late winter and spring when winds may average 20 mph for several days in succession.

New Mexico averages 300 sunny days a year. The mean annual insolation is exceeded only by Arizona and Death Valley, California (New Mexico Economic Development Division, 1982). This natural resource makes solar energy a viable energy option for heating the SSC facility and experimental halls.

Table 6-1. Average Temperatures in the Estancia Valley. (Data from Gabin and Lesperance, 1977 and pers. comm., K. Kunkel, State Climatologist, 1986).

Month	Temperature (°F) Max	Min	Mean
January	43.4	14.1	32.3
February	48.7	18.2	36.9
March	56.3	23.3	43.2
April	65.8	30.1	51.9
May	74.2	38.3	61.1
June	84.6	46.2	70.8
July	87.5	53.3	75.0
August	84.9	52.1	72.8
September	79.1	44.4	66.0
October	68.3	32.2	52.9
November	55.2	19.4	42.0
December	45.3	15.5	34.2
Annual			53.6

Table 6-2. Average Precipitation (inches) in the Estancia Valley (Data from Gabin and Lesperance, 1977).

Month	Station					
	Edgewood[1]	Otto[2]	Stanley[3]	Moriarty[4]	McIntosh[5]	Average
January	0.47	0.45	0.28	0.82	0.44	0.49
February	0.48	0.42	0.36	0.65	0.52	0.49
March	0.71	0.45	0.41	0.76	0.53	0.58
April	0.64	0.61	0.42	0.55	0.69	0.58
May	0.95	0.97	0.63	0.72	1.16	0.89
June	0.68	0.96	0.85	0.79	0.97	0.85
July	2.10	2.27	2.03	2.46	2.49	2.27
August	3.38	1.97	2.36	2.02	2.90	2.53
September	1.26	1.30	1.43	1.55	1.69	1.45
October	0.79	0.96	1.21	1.36	1.16	1.10
November	0.51	0.38	0.41	0.52	0.44	0.45
December	0.51	0.51	0.46	0.59	0.55	0.52
Annual	12.48	11.63	11.20	12.67	13.74	12.34

1. 15 yr average
2. 42 yr average
3. 21 yr average
4. 6 yr average
5. 45 yr average

7.0 REGIONAL RESOURCES

The needs for the SSC facility, beyond the technical necessities such as land availability and suitable geological conditions, include industrial resources, human resources, housing, educational facilities, and other infrastructure and socioeconomic resources. The close proximity of the SSC facility to Albuquerque and Santa Fe fills all of these infrastructure and socioeconomic needs.

7.1 Accessibility

The Estancia Valley site is readily accessible via I-40 and NM-41. These two roads can accommodate the long-bed vehicles and additional traffic generated by construction and operation of the SSC facility (pers. comm., David Albright, New Mexico State Highway Department, 1986). In addition, there are several paved roads in the study area that, with some upgrading, could serve the experimental sites. The SSC facility will require minimal additional construction of access roads.

Albuquerque International Airport is located 40 miles west of the study area and is readily accessible via I-40. The airport has 10 major air carriers, two commuter airlines, and air cargo capability. Operational limitations (e.g., snow/fog closure) are rare. The airport has never been closed for a full day due to weather conditions. In recent years, it has been closed once for two hours and once for three hours. Ground transportation facilities (limousine, bus, and rental car) are available at the airport (pers. comm., Jim Casias, Manager, Albuquerque International Airport, 1986). Connecting flights to Albuquerque from "hub" cities such as Dallas, Denver, and Atlanta can be used by scientists and other visitors. In addition, a local airport (in Moriarty) is under development. At the present time the runway length is 4,800 feet and it serves charter and private aircraft.

Other transportation needs of the SSC facility are railroads (both freight and passenger) and buses. Trailways Western Lines presently schedules three buses per day each way between Albuquerque and Moriarty. Amtrak rail passenger service provides both eastbound and westbound service to either coast, on a daily basis, with stops in Albuquerque and Lamy (25 miles north of the study area). The Santa Fe Railway provides daily mainline freight service to and from the Albuquerque area (pers. comm., Albuquerque Chamber of Commerce, 1986) and has overnight delivery from cities as far away as Denver, Colorado.

7.2 Industrial resources

Construction and operation of the SSC facility will require both specialized and conventional industrial services. These services include: compressed and liquified gases; industrial solvents; electrical and electronic fabricators; heavy-equipment maintenance and rental; and maintenance services (e.g., vehicles, computers, and office machines). The Albuquerque-Santa Fe area has a large array of firms offering sales and maintenance of industrial resources (pers. comm., Terry Allbrooks, Albuquerque Economic Committee, 1986), and I-40 makes possible timely courier delivery of goods to the study area.

7.3 Construction resources

Construction of the SSC will require large amounts of conventional construction materials and equipment. Of primary concern are cement, sand, and gravel, which are used in the manufacture of concrete. New Mexico produces noteworthy amounts of these commodities (U.S. Department of Interior, 1986) and could supply the concrete needed for construction. A major cement manufacturing plant is located in Tijeras (just south of I-40) approximately one-half way between Albuquerque and Moriarty. The Tijeras plant produces 1,600 tons per day of portland cement (pers. comm., Robert Eveleth, NMBMMR, 1986).

Other necessary construction resources include steel fabrication, electrical power equipment, construction equipment, and repair facilities. In the Albuquerque-Moriarty-Santa Fe area there are 30 steel fabricators and suppliers, 33 electrical equipment companies, and 25 construction equipment supply and repair companies. In addition, there are more than 100 construction contractors. During construction and operation the SSC facility could draw upon these resources.

7.4 Human resources

In addition to scientists, the SSC facility will require mechanical, electrical, and civil engineers; architects; machinists; computer operators; and other skilled and semi-skilled personnel.

The regional population distribution is ideally suited for the project. This allows construction of the project with a minimum of disruption (population density in the study area is approximately 2.5 person/mi^2) while simultaneously providing the labor and services from Albuquerque and Santa Fe.

Table 7-1 presents the occupation of employed persons in Santa Fe and Albuquerque (pers. comm., University of New Mexico, Government Publications Department, 1986). The table shows the abundance of engineers, professionals, technical support, and construction workers for the SSC facility to draw upon. The presence of the University of New Mexico, Sandia National Laboratories, and more than 100 high technology firms (pers. comm., Terry Allbrooks, Albuquerque Economic Development Council, 1986) mainly accounts for the abundance of engineering, professional, and technical personnel. This abundance not only implies the availability of local personnel to fill SSC facility positions, but also indicates that the area is capable of attracting technical personnel from outside the region.

When fully operational, the SSC will result in approximately 4,000 new jobs. The facility will require a permanent staff of 2,500 to 3,000 high-energy physicists,

Table 7.1 - Occupation of employed persons, 1980*

Category	Santa Fe	Albuquerque	New Mexico	U.S.
Employed persons 16 years and over	20,115	154,872	508,238	97,639,355
Managerial and professional	2,938	19,115	51,234	22,151,648
Professional specialty occupations	3,357	20,228	56,328	12,018,097
Engineers and natural scientists	758	5,876	15,090	1,382,095
Technical, sales, and administrative support	6,730	56,205	153,930	29,593,506
Service occupations	2,520	17,592	68,648	12,629,425
Precision productions, craft and repair	939	11,328	47,023	12,594,175
Construction trades	1,097	7,289	28,912	4,247,010
Operators, fabricators, and laborers	1,483	15,898	70,316	17,859,343
Percentages				
Managerial and professional	14.6%	12.3%	10.1%	22.7%
Professional specialty occupations	16.7%	13.1%	11.1%	12.3%
Engineers and natural scientists	3.8%	3.8%	3.0%	1.4%
Technical, sales, and administrative support	33.4%	36.3%	30.3%	30.3%
Service occupations	12.5%	11.3%	13.5%	12.9%
Precision productions, craft and repair	4.7%	7.3%	9.3%	12.9%
Construction trades	5.4%	4.7%	5.7%	4.3%
Operators, fabricators, and laborers	7.4%	10.3%	13.8%	18.3%

* Does not include agricultural employment.

other scientists, engineers, technicians, administrators, and support personnel. Another 1,000 to 1,500 workers will be employed to provide goods and services purchased for the SSC.

Table 7-2 presents the average weekly earnings by industrial workers for 1982. More detailed breakdowns by subcategory are also available (pers. comm., Theresa Marquez, University of New Mexico, Government Publications Department, 1986). A comparison shows that labor costs are lower in New Mexico compared to the U.S. average.

TABLE 7-2. Gross earnings of production or nonsupervisory employees, 1982.

Industry	Average weekly earnings (dollars) NM (1982)	U.S. (1982)
Manufacturing	282	330
Mining	471	460
Construction	386	427
Transportation and public utilities	379	402
Trade	244	308
Finance, insurance, real estate	186	245

Sources: pers. comm., Theresa Marquez, Government Documents Department, University of New Mexico; New Mexico Economic Development Division, 1982; U.S. Department of Commerce, 1985.

7.5 Housing and community services

The SSC will operate 24 hours a day. Therefore, personnel must live relatively close to the site. The housing needs will include: single-family homes (for sale or rent), apartments, and motels and hotels for short-term visitors.

Many of the SSC personnel will live in Albuquerque and Santa Fe. A characterization of housing available or planned shows approximtely 6,500 existing residential properties for sale; 4,000 new residential properties constructed annually; and up to 10,000 rental units available. The typical home purchase price is $90,000 in Albuquerque and $105,000 in Santa Fe (pers. comm., Michael Griego, U.S. Department of Housing and Urban Development, Albuquerque Office, 1986). Apartment rentals range from $200 to $850 per month with a typical rent of $400 per month. Rental of single-family homes averages $550 per month. The housing industry has the capability of producing 5,000 homes per year (pers. comm., Jack Milarch, president, New Mexico Home Builders Association, 1986).

Additional housing is available in the Estancia Valley. There are approximately 100 new and existing subdivisions (Fig. 7-1), mostly in the Edgewood-Moriarty area. In most of these subdivisions only a few houses have been built. They would be a convenient and available location for SSC personnel. For short-term visitors of the SSC there are approximately 190 motels and hotels with 15,000 units in the Moriarty-Albuquerque-Santa Fe area.

Community services needed by SSC personnel include medical, police, fire, rescue, and recreational. There are 11 hospitals with 2,265 beds available in Albuquerque and

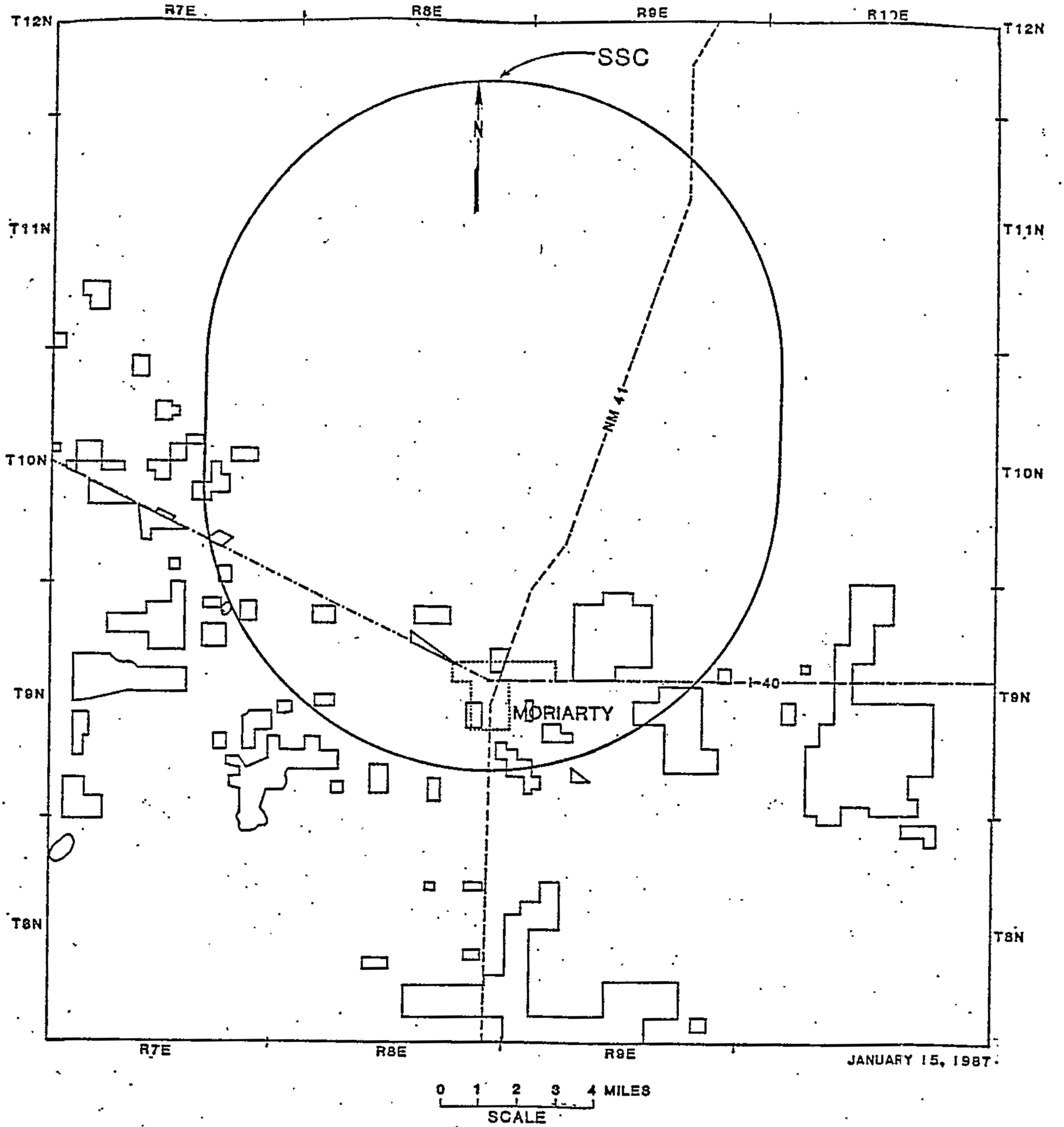

Figure 7-1. Subdivisions in the northern Estancia Valley (pers. comm., State Engineer's Office, 1986).

Santa Fe. Locally, Moriarty and Estancia each have a medical clinic. Rescue and ambulance services are available from hospitals, local fire departments (Edgewood and Stanley), and the Lifeguard helicopter service can fly critical cases to Albuquerque hospitals.

The fire service is supplied by the Edgewood, Stanley, McIntosh, and Moriarty fire departments (all on a volunteer basis). It would be desirable for the SSC facility to provide a local professional fire department. Law enforcement is provided by Moriarty and Estancia local police, and Torrance and Santa Fe County Sheriff's Departments. The New Mexico State Police has a substation in Moriarty.

Recreational facilities within the region include: University sports teams, sailing, skiing, State Fair, balloon fiesta, arts and crafts fairs, rodeos, minor league baseball, horse racing, golf courses, tennis courts, rafting, camping and hiking, horseback riding, an observatory, theaters, a zoo, parks, national monuments, and others. These recreational activities span all four seasons.

7.6 Educational and cultural resources

In Albuquerque and Santa Fe there are seven university and vocational-technical schools (5 in Albuquerque, 2 in Santa Fe) with a combined enrollment of approximately 46,000 students. Among the programs offered at these schools are technological, scientific, recreational, law, medical, arts, language, historical, business, and vocational. Undergraduate, masters, and doctoral programs are available. There are 134 public schools serving kindergarten through grade 12, with a combined enrollment of approximately 97,000. In addition, there are 44 private and parochial schools with approximately 12,000 children enrolled (pers. comm., Albuquerque Public Schools, 1986). On verbal SAT tests Albuquerque students scored 55 points above the national average and on math 54 points above the national average.

The cultural resources of the area include: 14 libraries, 14 museums, 21 performing arts centers, 480 places of worship, 247 art galleries, 5 civic halls (with combined seating for over 50,000 persons), an opera, state parks, fiestas, native American markets and pueblos, and numerous other events.

7.7. Community support

The assessment of community support for the SSC facility can be based on contacts with local residents that the SSC Staff (NMBMMR) had while doing field work. We received encouragement and cooperation from local farmers, ranchers, businessmen, and administrators (e.g. "Torrance County is very much interested in having the Super Collider facility located in our county," Phyllis Vespignani, Administrative Assistant).

No landowners refused access to the SSC staff during drilling, trenching, and mapping, and utility companies have expressed a willingness to facilitate utility tie-ins for the SSC (see Sec. 5.0).

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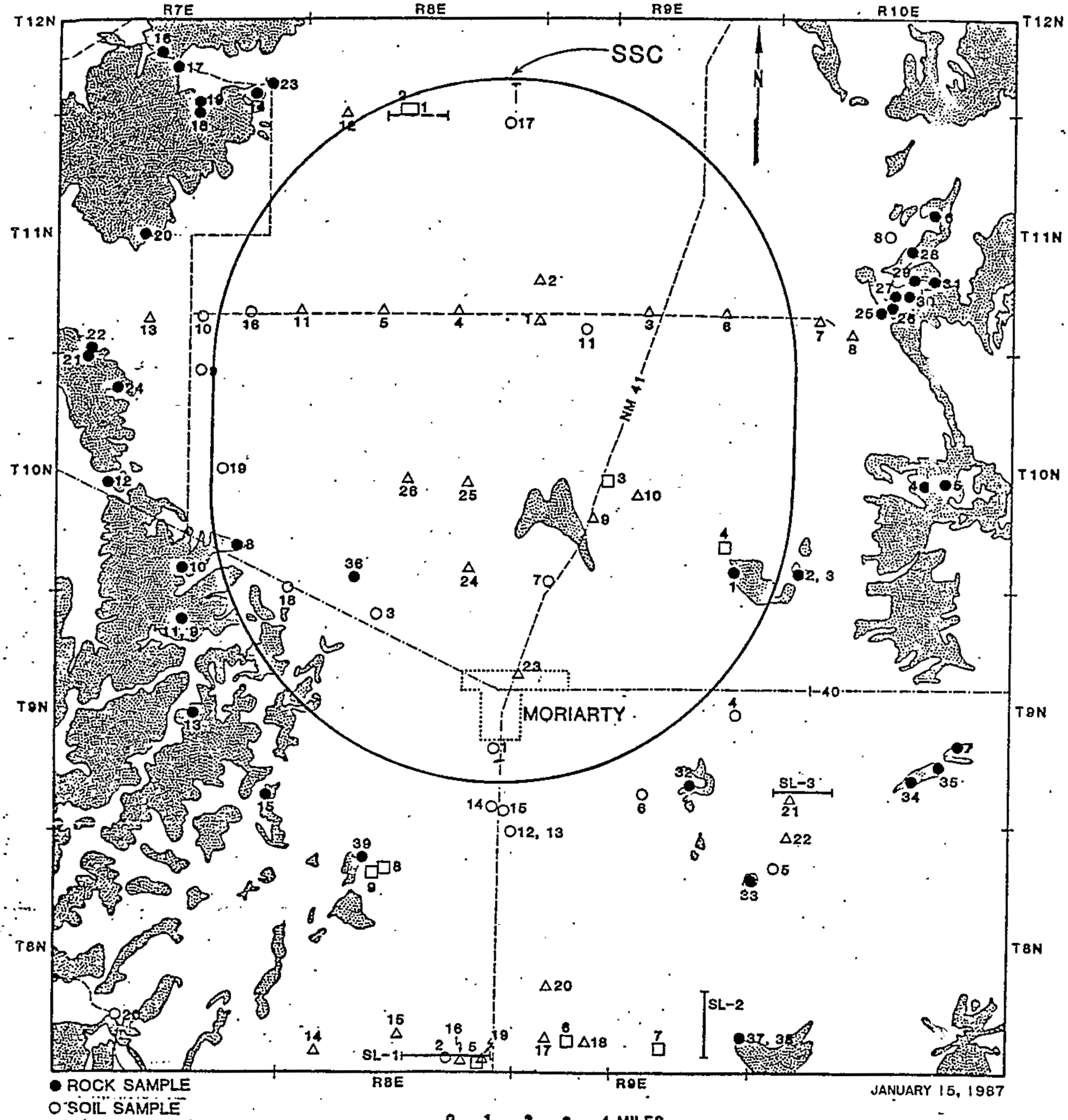
9.0 APPENDIX

Activity location map

Trench logs

Boring logs

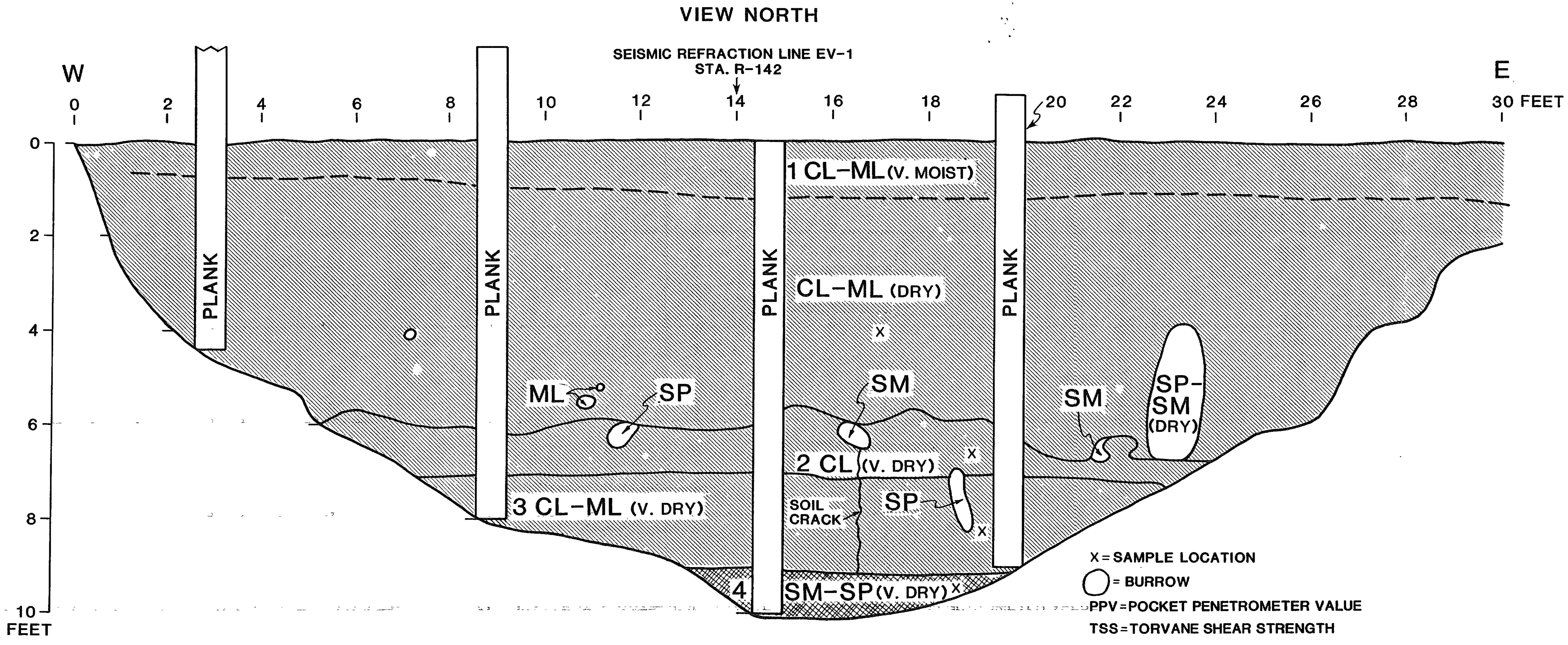


● ROCK SAMPLE
○ SOIL SAMPLE
△ EXPLORATORY DRILL HOLE
□ EXPLORATORY TRENCH
├ - - ┤ SEISMIC REFLECTION SURVEY
├──┤ TOPOGRAPHIC SURVEY LINE

Figure A-1 Activity Location Map

TRENCH LOGS

The following five trench logs are representative of the nine logs completed during the study. They show the soil types and their stratigraphic relationships within the upper 12 feet of the valley fill. Trench locations are shown on the Activity location map and test data are shown in Table 4-2.



UNIT

1 CL-ML, SILTY CLAY-SANDY SILT, V. MOIST AT SURFACE, DRY BELOW 1 FOOT, SOFT AT SURFACE, STIFF BELOW 1 FOOT, CONTAINS GRAVEL SIZE CLASTS OF IGNEOUS AND LIMESTONE ROCK (SUBANGULAR), $CaCO_3$ NODULES AND FILAMENTS.

2 $CaCO_3$ (CL), SILTY CLAY, V. DRY, STIFF, LAMINAR-SUBLAMINAR STAGE IV IN PLACES, BROKEN INTO GRAVEL SIZE PIECES THROUGHOUT. EXTENSIVELY BURROWED. BURROWS FILLED WITH FINE DARK COLORED SP-SM, GRAVELLY SAND-SILTY SAND, DRY, SOFT.

3 CL-ML, SILTY CLAY-SANDY SILT, V. DRY, SOMEWHAT BURROWED.

4 SM-SP, SILTY SAND-FINE SAND, V. DRY, SCATTERED CARBON.

NOTES:

SOIL CRACK IS COATED WITH $CaCO_3$, NO OFFSET NOTED.

SMALL ROOTS TO 6 FEET.

NO EVIDENCE FOR FAULTING IN TRENCH.

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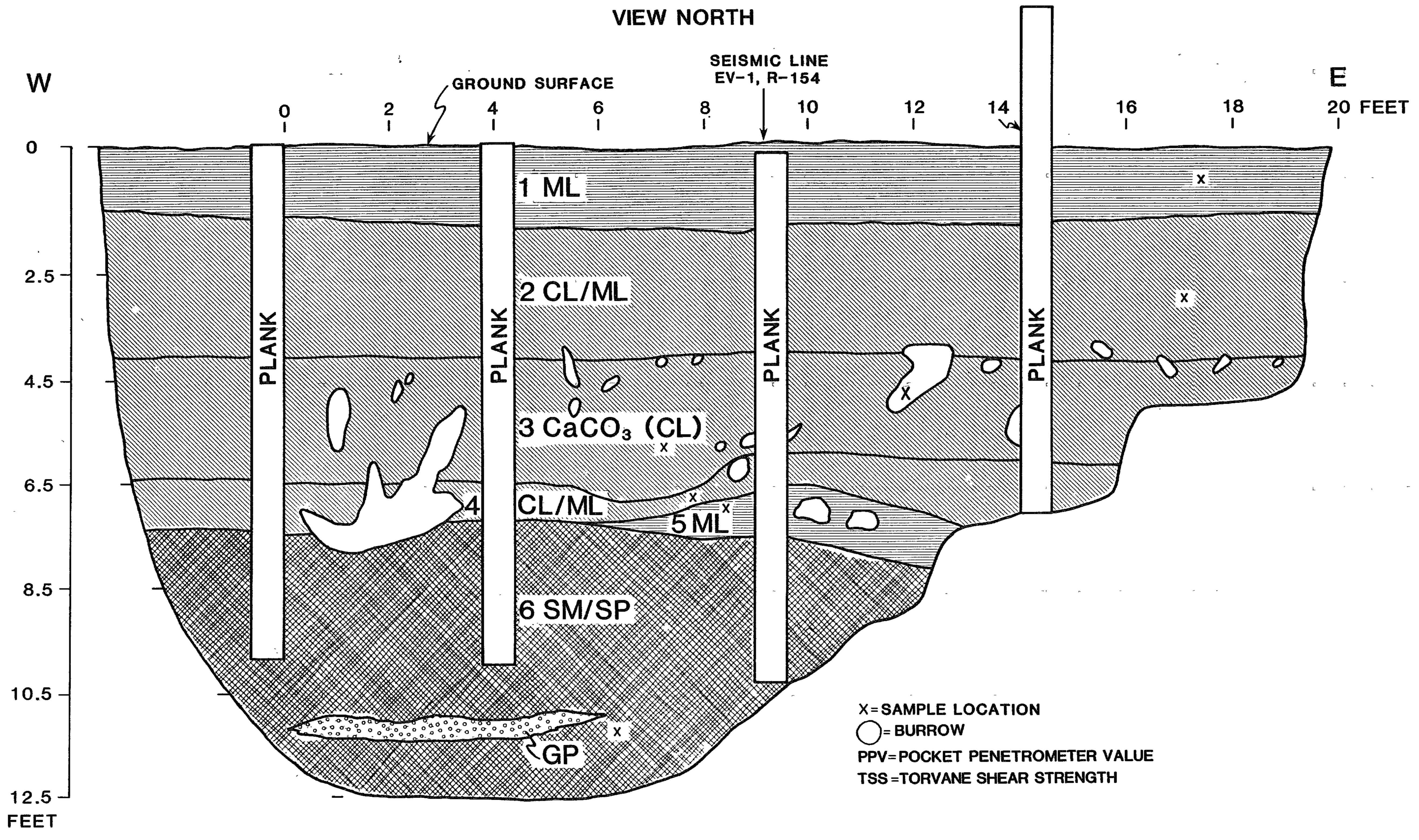
SSC PROJECT
LOG OF TRENCH SSC-BH-1

JANUARY 15, 1987



UNIT

1 ML, SANDY SILT, MOIST, SOFT, PPV = 1.0 kg/cm^2, MANY ROOTS.

2 CL-ML, SILTY CLAY-SANDY SILT, DRY, HARD, PPV > 4.5 kg/cm^2, CONTAINS FILAMENTS AND NODULES, MANY ROOTS.

3 CL, $CaCO_3$, SILTY CLAY, DRY, HARD-V. HARD, WHITE, STAGE III (NO LAMINAE), PPV > 4.5 kg/cm^2.

4 CL-ML, SILTY CLAY-SANDY SILT, HARD, PPV > 4.5 kg/cm^2.

5 ML, SANDY SILT, DRY, SOFT, FINELY LAMINATED FINE SAND, PPV < 0.5 kg/cm^2, CONTAINS .25 INCH SIZE INTRACLASTS OF CLAY, RODENT BONES.

6 SM-SP, SILTY SAND-GRAVELLY SAND, DRY, MED. DENSE, PPV > 4.5 kg/cm^2, DISCONTINUOUS GRAVEL LENSES.

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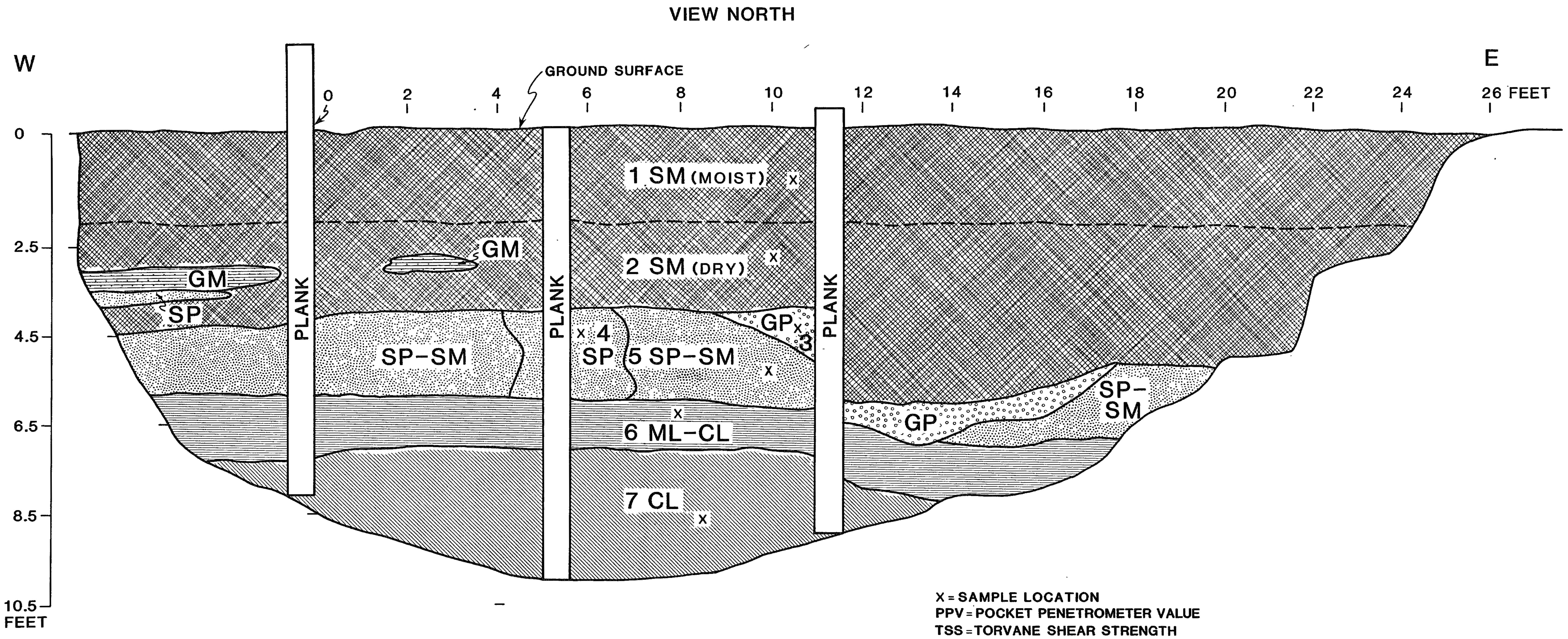
LOG OF TRENCH SSC-BH-2

JANUARY 15, 1987



UNIT

1 SM, SILTY SAND, S. MOIST, LOOSE.

2 SM, SILTY SAND-GRAVELLY LENSES OF GM, SILTY GRAVEL AND SP, CLEAN SAND, DRY, LOOSE, SNAIL SHELLS.

3 GP, GRAVEL-SAND MIX, LOOSE.

4 SP, FINE SAND.

5 SP-SM, FINE SAND-SILTY SAND, DRY, MED. DENSE TO LOOSE, LAMINATED.

6 ML-CL, SANDY SILT-SILTY CLAY, DRY, STIFF, PPV>4.5 kg/cm^2.

7 CL, SILTY CLAY, DRY-S. MOIST, STIFF-HARD, PPV>4.5 kg/cm^2, WHITE.

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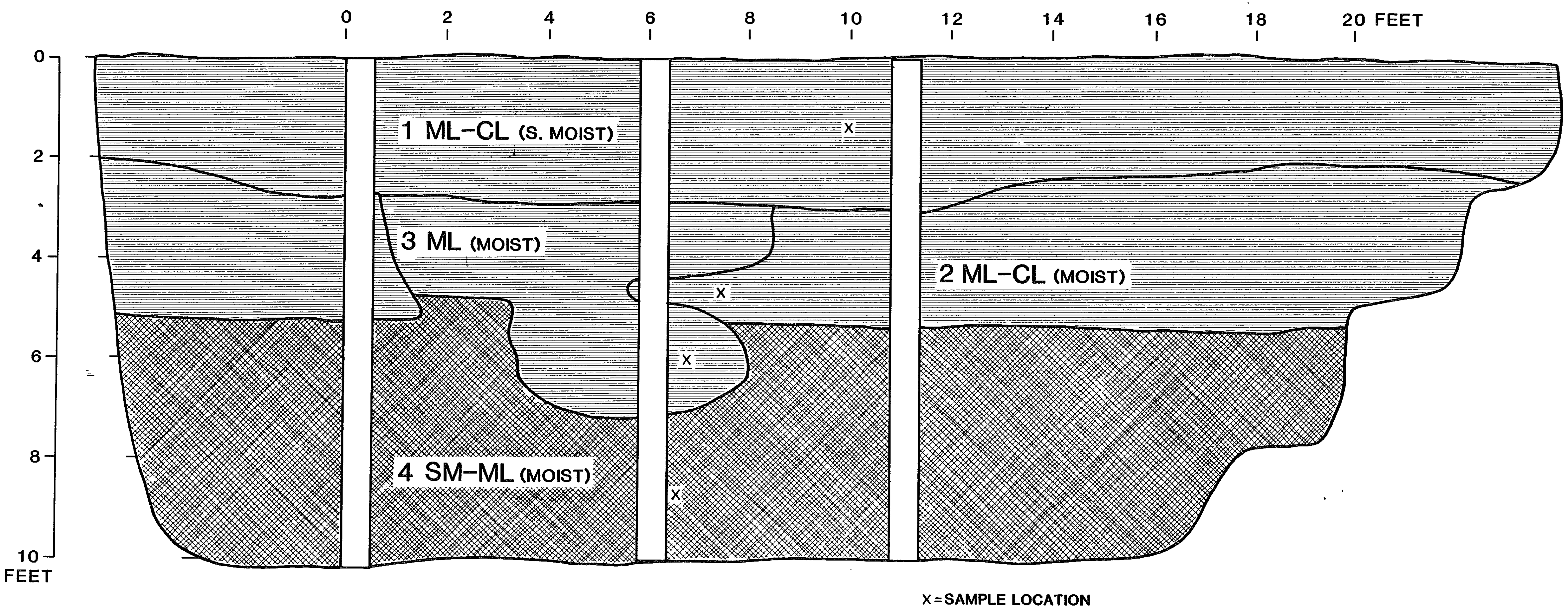
LOG OF TRENCH SSC-BH-4
MONTOYA RANCH

JANUARY 15, 1987

VIEW NORTH



UNIT

1 ML-CL, SILT TO SILTY CLAY, MOIST, PPV = 2.0kg/cm^2, TSS = 1.5kg/cm^2, ORGANIC RICH, HEAVILY BURROWED, MANY $CaCO_3$ NODULES, SOME REWORKED CLASTS FROM UNIT 2 BELOW, DARK YELLOWISH BROWN (POSSIBLY ALLUVIUM).

2 ML-CL, CLAY TO SILTY CLAY, MOIST, HARD, PPV > 4.5kg/cm^2, TSS = 9.5kg/cm^2, FINE ROOTS, CONTACTS BETWEEN UNITS ABOVE AND BELOW ARE SHARP, V. PALE BROWN (LAKE).

3 ML, SILT TO SANDY SILT, MOIST, SOFT, PPV = 1.5kg/cm^2, TSS = 0.5kg/cm^2, MORE ORGANIC THAN OTHER UNITS, DISTINGUISHED FROM OTHER UNITS BY DARKER COLOR, STRONG REACTION TO HCl; FINE ROOTS, YELLOWISH BROWN.

4 SM-ML, SILTY SAND TO SILT, MOIST, HARD, PPV > 4.5kg/cm^2, TSS = 3.0kg/cm^2, FEW ROOTS, STRONG REACTION TO HCl, GRADATIONAL CONTACT TO UNIT 3 ABOVE, STRONG BROWN.

X = SAMPLE LOCATION
PPV = POCKET PENETROMETER VALUE
TSS = TORVANE SHEAR STRENGTH

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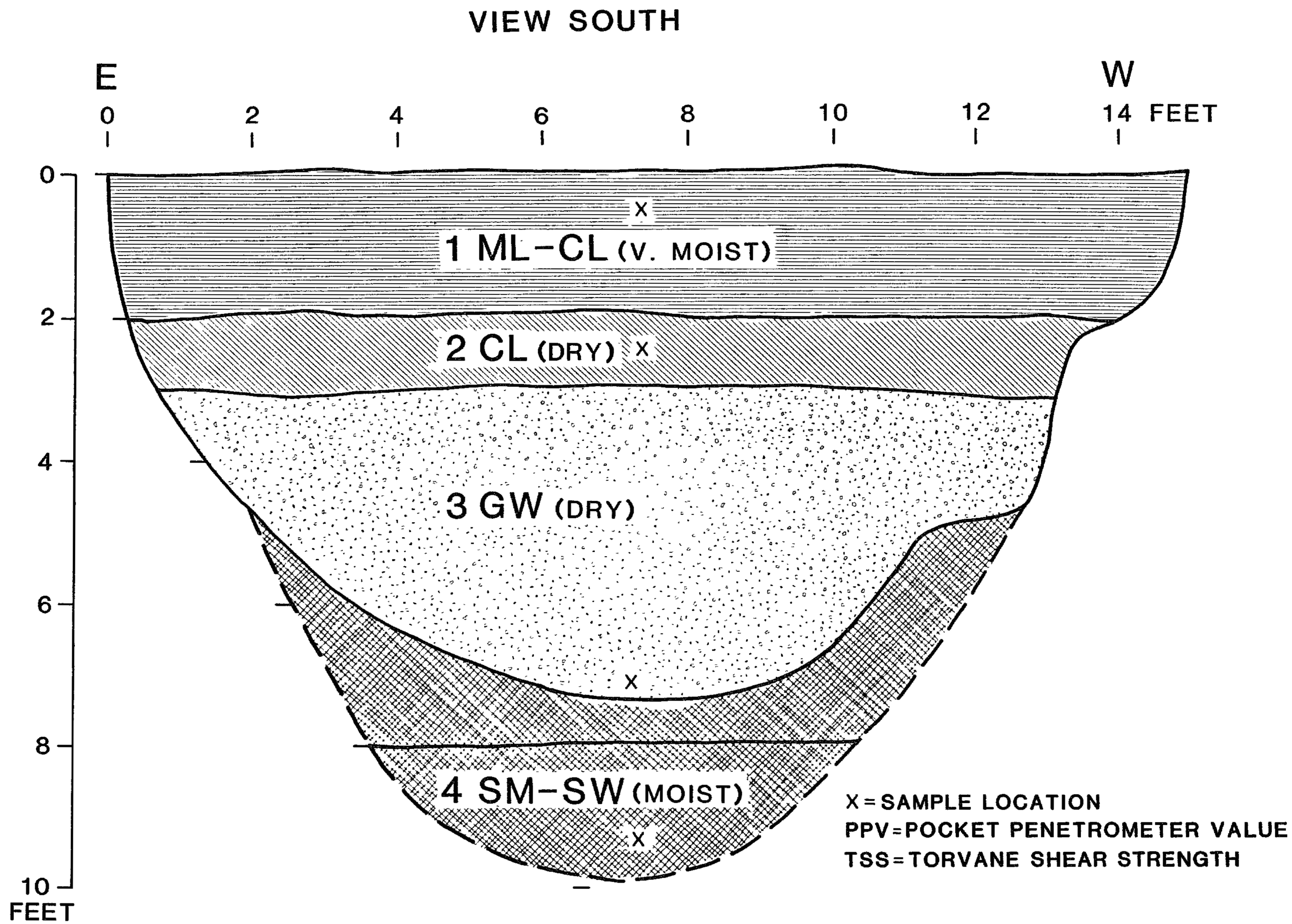
LOG OF TRENCH SSC-BH-8

JANUARY 15, 1987



UNIT

1 ML–CL, SILTY CLAY TO CLAY, V. MOIST, SOFT, VERY ORGANIC, ABUNDANT WORMS AND WORM BURROWS, SCATTERED GRAVEL (FINE TO MEDIUM).

2 $CaCO_3$ (CL), DRY, STAGE IV

3 GW, SANDY GRAVEL WITH BOULDERS AND COBBLES, DRY, ALL CLASTS ARE MADERA LIMESTONE SUBANGULAR TO SUBROUNDED, MOST ARE WELL COATED WITH $CaCO_3$.

4 SM–SW, SILTY SAND WITH GRAVEL, MOIST, DENSE, CLASTS TO 0.5 INCH SUBROUNDED, ALL MADERA LIMESTONE, BROWN TO DARK BROWN.

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SSC PROJECT
LOG OF TRENCH SSC-BH-9

JANUARY 15, 1987

BORING LOGS

The following five boring logs are representative of the 29 logs completed for the study. They show the geotechnical conditions within the upper 45 feet of the valley fill. Boring locations are shown on the Activity location map and test data are shown in Table 4-2.

ELEVATION (ft.)	DEPTH (ft.)	"N" VALUE STD. PEN. TEST	MOISTURE (% of dry wt.)	DRY DENSITY (lbs./cu. ft.)	LIQUID LIMIT	PLASTIC LIMIT	SAMPLE TYPE U=Undisturbed D=Disturbed	USCS SYMBOL	GEOLOGIC SYMBOL	SOIL DESCRIPTION Gravel/Sand/Finer (%)
6276	4-5½	6	7		21	NP	D	SM		Silty sand 0/79/21
6271	9-10½	27	16		53	22	D	CH		Clay 0/3/97
6261	19-20½	26	12		25	19	D	SM/SC		Silty sand/clayey sand 0/64/36
6251	29-30½	27	9		30	9	D	SC		Clayey sand 0/71/29
6241	39-40½	25	13		28	16	D	CL		Clay 0/41/59

BORING: SSC-DH-2
DATE DRILLED: 9/23/86
EQUIPMENT USED: SIMCO 2800 HS
LOCATION: NE¼ NE¼ SEC25 T11N R8E
ELEVATION: 6280
TOTAL DEPTH: 40.5 feet

THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

NOTES: Don King Ranch
Heavy rains

NV=no value
NP=non-plastic

NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES
SSC PROJECT

BORING LOG

BORING: SSC-DH-4
DATE DRILLED: 9/25/86
EQUIPMENT USED: SIMCO 2800 HS
LOCATION: SE¼ SE¼ SEC27 T11N R8E
ELEVATION: 6318
TOTAL DEPTH: 30 feet

THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

ELEVATION (ft.)	DEPTH (ft.)	"N" VALUE STD. PEN. TEST	LABORATORY DATA: MOISTURE (% of dry wt.)	DRY DENSITY (lbs./cu. ft.)	LIQUID LIMIT	PLASTIC LIMIT	SAMPLE TYPE U=Undisturbed D=Disturbed	USCS SYMBOL	GEOLOGIC SYMBOL	SOIL DESCRIPTION Gravel/Sand/Fines (%)
6314	4-5	14	10		26	17	D	SC		Clayey sand 1/69/30
6309	9-10	9	11		23	NP	D	SM		Silty sand 0/72/28
6299	19-20	29	7		25	21	D	SM/SC		Silty sand/clayey sand 0/69/31
6289	29-30	39	13		32	17	D	SC		Clayey sand 0/60/40

NOTES: On Highway 471, 2½ miles west of Don King Ranch.
Drilled by G.J.

NV=no value
NP=non-plastic

NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES
SSC PROJECT

BORING LOG

BORING: SSC-DH-9
DATE DRILLED: 9/30/86
EQUIPMENT USED: SIMCO 2800 HS
LOCATION: NE¼ NW¼ SEC29 T10N R9E
ELEVATION: 6229
TOTAL DEPTH: 30 feet

ELEVATION (ft.)	DEPTH (ft.)	"N" VALUE STD. PEN. TEST	LABORATORY DATA MOISTURE (% of dry wt.)	DRY DENSITY (lbs./cu. ft.)	LIQUID LIMIT	PLASTIC LIMIT	SAMPLE TYPE U=Undisturbed D=Disturbed	USCS SYMBOL	GEOLOGIC SYMBOL	SOIL DESCRIPTION Gravel/Sand/Fines (%)
6225	4-5	12	13		24	20	D	CL/ML		Silty clay 0/43/57
6220	9-10	15	10		25	19	D	SM/SC		Silty sand/clayey sand 0/65/35
6210	19-20	25	19		42	24	D	SC		Clayey sand 0/53/47
6200	29-30	45	14		36	23	D	CL		Clay 0/25/75

THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

NOTES: On Highway 41 right of way, near King Brothers Feed Lot.
Drilled by G.J.

NV = no value
NP = non-plastic

NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES
SSC PROJECT

BORING LOG

BORING: SSC-DH 10
DATE DRILLED: 101 186
EQUIPMENT USED: SIMCO 2800 HS
LOCATION: Central SEC21 T10N R9E
ELEVATION: 6220
TOTAL DEPTH: 30 feet

ELEVATION (ft.)	DEPTH (ft.)	"N" VALUE STD. PEN. TEST	LABORATORY DATA: MOISTURE (% of dry wt.)	LABORATORY DATA: DRY DENSITY (lbs./cu. ft.)	LABORATORY DATA: LIQUID LIMIT	LABORATORY DATA: PLASTIC LIMIT	SAMPLE TYPE U=Undisturbed D=Disturbed	USCS SYMBOL	GEOLOGIC SYMBOL	SOIL DESCRIPTION Gravel/Sand/Fines (%)
6216	4-5	21	13		20	NP	D	SM		Silty sand 0/67/33
6211	9-10	36	6		NP	NP	D	SW/SM		Sand/silty sand 5/88/7
6201	19-20	12	15		20	16	D	CL/ML		Silty clay 0/42/58
6191	29-30	32	13		21	12	D	CL		Clay 0/37/63

THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

NOTES: In potatoe field on King Brother's feed lot.
Drilled by S.R.C.

NV=no value
NP=non-plastic

NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES
SSC PROJECT

BORING LOG

BORING: SSC-DH-12
DATE DRILLED: 10/20/86
EQUIPMENT USED: SIMCO 2800 HS
LOCATION: SE¼ SE¼ SEC31 T12N R8E
ELEVATION: 6660
TOTAL DEPTH: 20.5 feet

ELEVATION (ft.)	DEPTH (ft.)	"N" VALUE STD. PEN. TEST	LABORATORY DATA: MOISTURE (% of dry wt.)	DRY DENSITY (lbs./cu. ft.)	LIQUID LIMIT	PLASTIC LIMIT	SAMPLE TYPE U=Undisturbed D=Disturbed	USCS SYMBOL	GEOLOGIC SYMBOL	SOIL DESCRIPTION Gravel/Sand/Fines (%)
6656	4-5½	33	7		25	20	D	SM/SC		Silty sand/clayey sand 0/64/36
6651	9-10½	19	6		24	18	D	SM/SC		Silty sand/clayey sand 0/61/39
6641	19-20½	20	8		29	19	D	SC		Clayey sand 0/60/40

NOTES: At Hyer near seismic line.
Drilled by G.J.

NV=no value
NP=non-plastic

NEW MEXICO BUREAU OF MINES AND MINERAL RESOURCES
SSC PROJECT

BORING LOG

THE LOG OF SUBSURFACE CONDITIONS SHOWN HEREON APPLIES ONLY AT THE SPECIFIC BORING LOCATION AND AT THE DATE INDICATED. IT IS NOT WARRANTED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.